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A Comparison of GPS Schmidt-Cassegrain Telescopes

	Meade 8", 10", 12", 14" LX200GPS	Competing 8" and 11" GPS
Primary Mirror Lock	Yes; standard equipment. Cancels residual mirror shift during visual, photographic, or CCD imaging applications	No
Zero Image-Shift Microfocuser	Yes; standard equipment. Operates from Autostar II handbox and permits 4-speed microfocusing, while maintaining precise image centration during CCD imaging	No; must be purchased separately from an alternate supplier at a cost of approx. $200 to $300
Download of Software Revisions	Yes; the latest software version, as well as custom and updated guided tours, comet and asteroid positions, may be downloaded in minutes, and at no charge, from the Meade website	No; software and data stored in the hand controller are not updatable without returning the hand controller to the factory; motor control software upgrade or debugging requires complete replacement of the electronic circuit board in the fork arm assembly
Software Download, Automatic GO TO, and Automatic Tracking of Earth Satellites	Yes; current earth satellite orbital data (including International Space Station, Space Shuttle, etc.) may be downloaded; telescope then automatically acquires and tracks satellite at correct tracking rate	No
True-Level Tripod Sensor	Yes; automatically compensates to a precision of 10-arcminutes for user error in leveling tripod during GPS alignment	No; absence of true-level sensor requires user to precisely level the tripod **manually**. Mis-leveling of the tripod by user results in alignment star errors of up to 5° or more during GPS alignment
Maximum Slew Speed	8° per second	3° per second
Time Required to Perform a 120° Slew	15 seconds	40 seconds
Drive Speeds, each axis	185 speeds, from 0.01x sidereal to 8° per second	9 speeds, from 0.5x sidereal to 3° per second
Tracking Rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Celestial Object Database	147,541 objects	40,000 objects
High-Precision Pointing Mode	Yes; permits GO TO pointing precision within 1-arcminute	No
Flash Memory	3.5-Meg	1.0-Meg
Permanent Periodic Error Correction	Yes, both axes	One axis only; second axis unprogrammable
Encoder Resolution	0.14 arcsecs	0.26 arcsecs
Internal Battery Compartments for cordless powering	Yes; user-supplied C-cell batteries located inside the fork arms negate any need for external power cords. (If desired, telescopes may alternately be powered by external cord.)	No
Multi-Coated Correcting Plate	Included with optional UHTC; increases light transmission by about 2% and reduces internal tube reflections	Not included and not available as an option
Enhanced Optical Coatings	Optional UHTC group results in light transmission **greater than 85%** at **all** wavelengths between 450nm - 700nm and transmission of **90% to 94%** at wavelengths between 540nm - 690nm, a range which includes the important Hα line at 656nm	Competing 11" coatings have a **peak** transmission of 85% at 510nm; **light transmission at all other visual wavelengths, including the Hα line, is below 85%**
Hand-Matched Optics	Yes; since their inception in 1980 all Meade Schmidt-Cassegrain optics have been individually hand-matched. Individual match-figuring is performed on the large correcting plate, resulting in a smooth optical figure	Yes; individual matching is performed on the small secondary mirror
Primary Mirrors	Oversize diameters (8.25" on 8" LX200GPS; 10.38" on 10" LX200GPS; 12.38" on 12" LX200GPS) result in increased edge-of-field illumination	Mirror diameters (8" telescope includes 8.1" mirror; 11" includes 11.1" mirror) result in lower edge-of-field illumination
GPS Antenna	Omnidirectional, located squarely on top of fork arm; GPS signals are receivable through a larger sky-area	Omnidirectional, but location at approx. 45° angle inside fork arm results in approx. 45° sky-area being inaccessible to GPS signals
Field Tripods	8" and 10" tripods include 2"-dia. chromed steel legs; 12" and 14" tripods include 3"-dia. chromed steel legs; all tripods include a **cast aluminum** leg-lock spreader bar	8" and 11" tripods include 2"-dia. painted steel legs and a **plastic** leg-lock spreader bar
Polar Axis Bearings	1 x 4" dia. ball bearing and 1 x 2.25" dia. ball bearing mounted coaxially to the polar axis. Both bearings contribute to radial and axial stiffness	1 x 1.88" dia. roller bearing mounted coaxial to the polar axis and 3 x 0.88" dia. ball bearings rolling on an unshielded aluminum track. Only the 1.88" bearing contributes to radial stiffness
Swing-through of optical tube in fork arms	Yes; telescope can observe 100% of sky area	Yes; telescope can observe 100% of sky area
FCC (U.S.A.) and CE (Europe) certified for low electromagnetic interference	Each telescope carries a label confirming FCC and CE certifications	Telescopes do not carry any labels confirming domestic or foreign certifications

Comparisons are based on current Meade LX200GPS models and on competitive telescopes and user manuals received in 11/2002.

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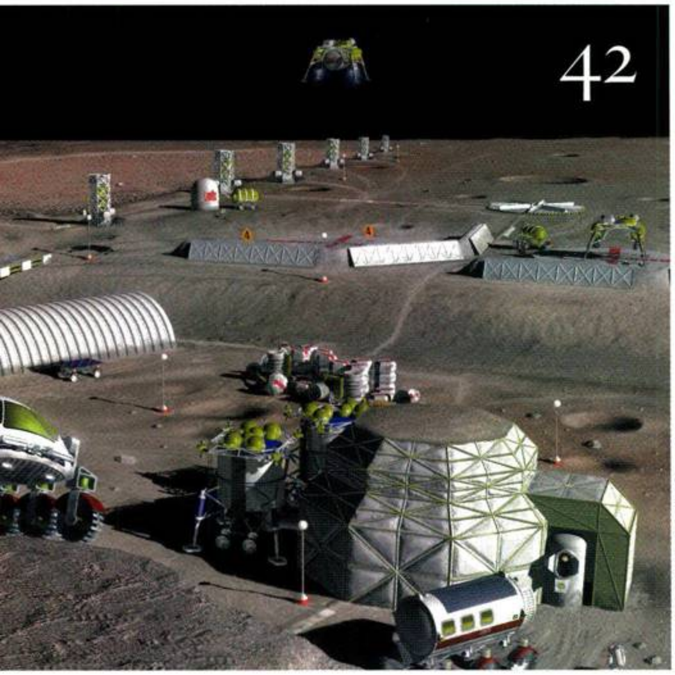

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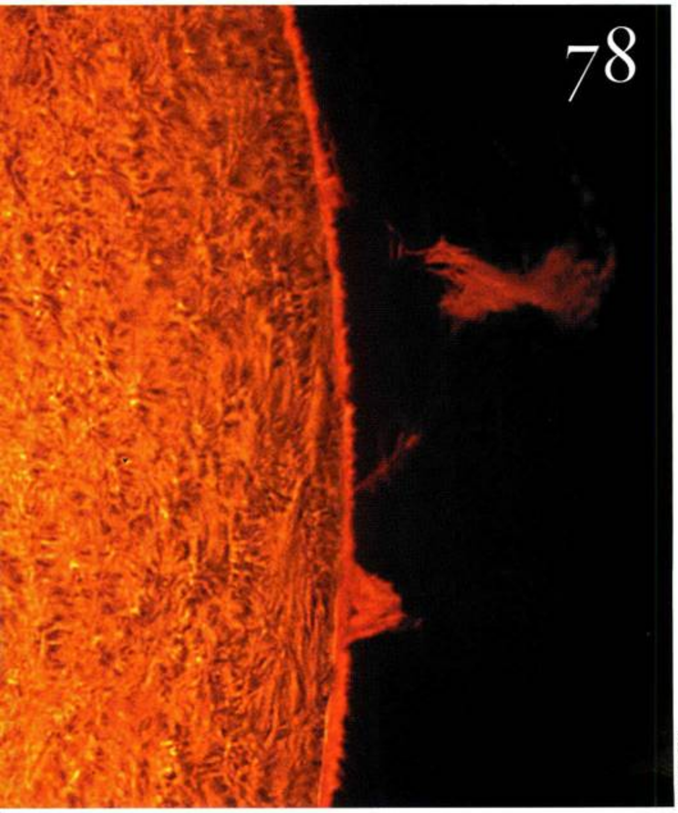

JACK NEWTON

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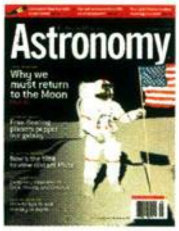

ON THE COVER
Astronaut Alan B. Shepard, Jr., stands beside a U.S. flag in his first moments on the lunar surface during Apollo 14, on February 5, 1971. Shadows are visible outlining the lunar module and fellow astronaut Edgar Mitchell. NASA/JSC

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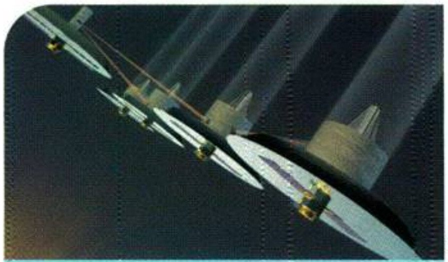

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BY DAVID J. EICHER

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We all have lived through another nightmare, another endless loop of video footage to watch over and over as we say, "how could this have happened?" Despite the subconscious worries about the aging shuttle fleet and the fragility of the spacecraft, we all believed that shuttle flights had become so routine that everything would be OK.

In the wake of the third shocking tragedy in NASA's history, we ponder the same questions that stirred with Apollo 1 and Challenger: Why send humans into space? Can the money be better spent elsewhere? Can't we do more actual science with unmanned solar system probes and orbiting telescopes anyway?

In "Harvest the Moon" (page 42), planetary scientist Paul Spudis makes a compelling case that space exploration by humans should continue unabated. Spudis studies the Moon and focuses on the scientific and technological answers that may be uncovered by a return to our nearest celestial neighbor. The Moon's rocks hold a history of the solar system's past that has been obliterated by Earth's weathering and geological processes. Lacking an atmosphere, the Moon would offer a stable platform for making pristine observations of the cosmos. It also offers a reasonable stepping-off point toward more ambitious programs, such as eventually sending humans to Mars.

As Deputy Leader of the science team for the Clementine lunar mission, Spudis knows what it takes to succeed with lunar science. He feels it's ironic that people believe we could return to the Moon at will because we did it so long ago. But we no longer have the equipment ready for a human lunar mission. If we are to return, it will take a commitment and determination, not just to say that we did it, as in the 1960s, but to reap the resources.

ASSOCIATE EDITOR Michael Bakich brings experience to *Astronomy*. *ASTRONOMY*: WILLIAM ZUBACK

Back down on Earth, we welcome a new associate editor to our *Astronomy* team, Michael E. Bakich. Michael earned his astronomy degree from Ohio State University and a degree in planetarium education from Michigan State. He has written three books on astronomy, all for Cambridge University Press. His latest, recently released, is *The Cambridge Encyclopedia of Amateur Astronomy*.

Michael is widely experienced as a planetary and deep-sky observer and enjoys collecting 19th-century astronomy books. Please welcome Michael — I know that you will enjoy his work in future editions of the magazine.

Yours truly,

DAVID J. EICHER
Editor

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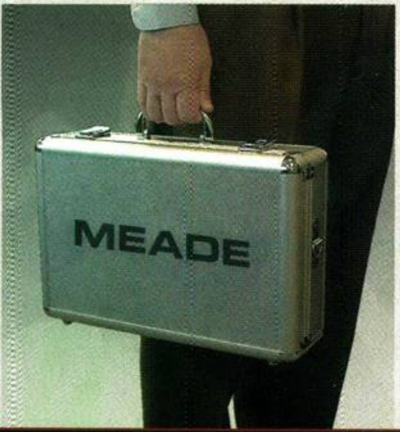

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SP15mm	79.95
SP20mm	79.95
SP26mm	(standard equipment)**
SP32mm	99.95
SP40mm	99.95
#771 Aluminum Carrying Case	49.95
Total price if purchased separately:	**$649.60**

***Telescopes qualifying for this special offer include:**

ETX models: ETX-90EC, ETX-105EC, ETX-125EC

LXD55 models: 6" SN-6, 8" SN-8, 10" SN-10, 8" SC-8, 5" AR-5, 6" AR-6, 6" SN-6EC, 8" SN-8EC, 5" AR-5EC

LX90, LX200GPS models: 8" LX90; 7", 8", 10", 12", 14", 16" LX200GPS

HOW TO ORDER

1. Buy any qualifying Meade telescope from an authorized Meade dealer in the U.S.A. between August 15, 2002 and June 30, 2003.

2. Fax or mail a copy of your dealer's invoice, plus the completed warranty card packed with the telescope, along with your payment of $99 to Meade Instruments/Attn: Customer Service, and request the "$99 Eyepiece Offer." *Requests must include your complete shipping address and phone number.*

3. We will ship your eyepiece package to you within 30 days of our receipt of your request. Meade Instruments will pay for all shipping and insurance charges; safe arrival is guaranteed.

Other terms and conditions: Payment may be made by personal check (payable to Meade Instruments) or credit card (VISA or MasterCard). **California residents must add $7.67 sales tax, for a total payment of $106.67.** Requests for this special offer must be postmarked not later than July 31, 2003. This special offer is valid only for new Meade telescopes ordered and received within the U.S.A. (Outside the U.S.A. contact your Meade international distributor.) There is no limit to the quantity of telescopes each person may order: each qualifying telescope is eligible to receive the special eyepiece package. Prices shown are suggested U.S. mail-order retail prices. **The SP26mm eyepiece (shown in photos above) is packed with each qualifying telescope as standard equipment.

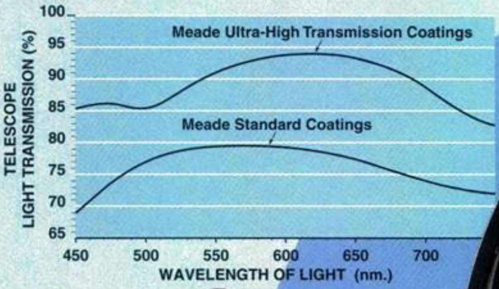
ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. ■ *A NASDAQ® company.*
6001 Oak Canyon, Irvine, California 92618 ■ (949) 451-1450
1-800-62-MEADE ■ FAX: (949) 451-1460 ■ *www.meade.com*

LXD55

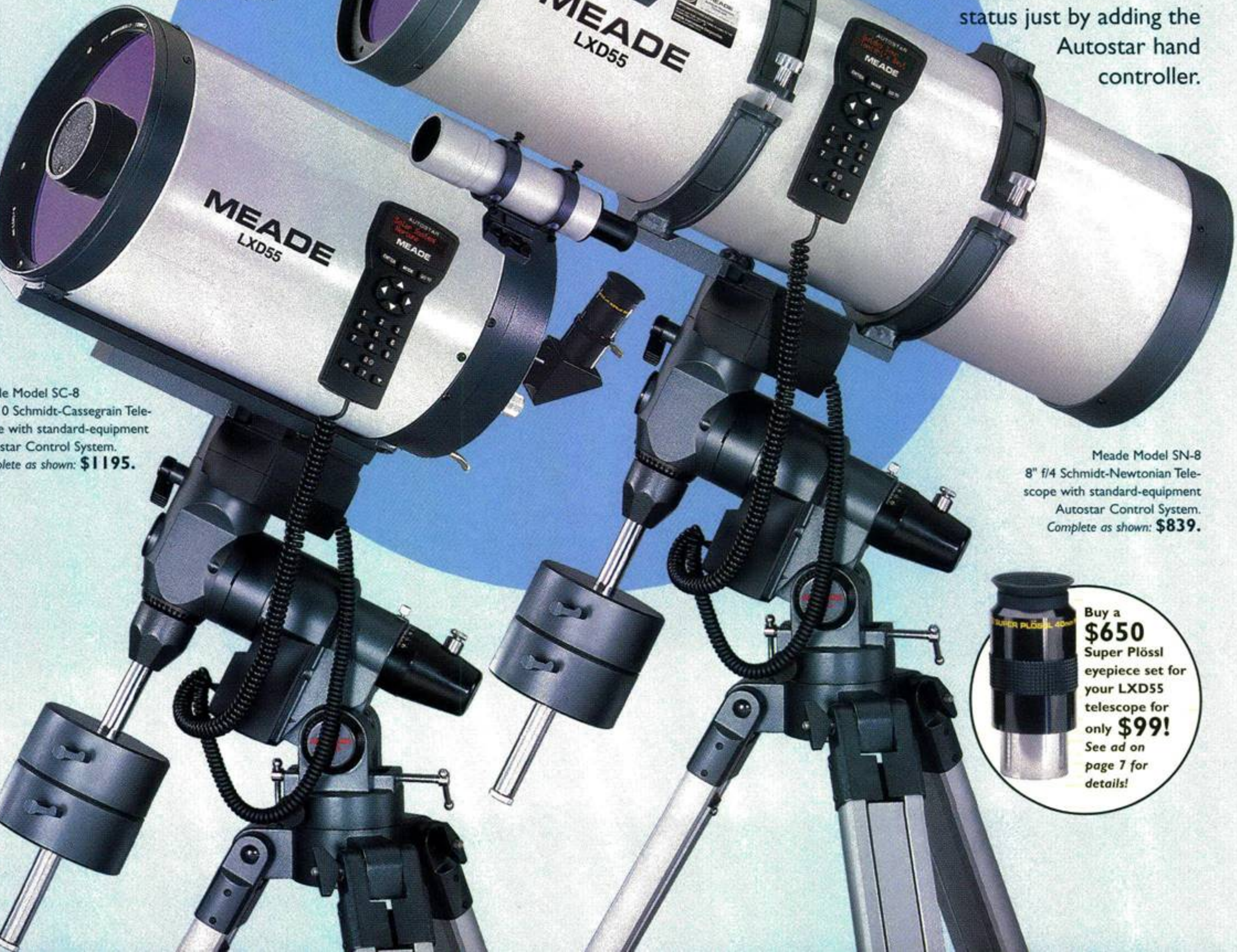
MEADE

Choose from nine Meade Schmidt-Newtonians, Schmidt-Cassegrain, and Achromatic Refractors, each with Autostar® or Electronic Controller — from $579, *complete!*

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by about 20% over the visible spectrum.



Observe ***hundreds*** of galaxies, nebulae, and star clusters of all types ***your very first night out,*** and hundreds more the next night out, simply by pressing the Autostar GO TO pushbutton. Watch as the telescope fast-slews at 4.5°/second, locating each object — from the brightest to the most obscure — and placing it automatically, unerringly, and precisely in the telescopic field. Or choose one of the new EC-models with dual-axis Electronic Controller, telescopes upgradable at any time in the future to full GO TO status just by adding the Autostar hand controller.



Meade Model SC-8
8" f/10 Schmidt-Cassegrain Telescope with standard-equipment Autostar Control System.
Complete as shown: **$1195.**

Meade Model SN-8
8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.
Complete as shown: **$839.**

Buy a $650 Super Plössl eyepiece set for your LXD55 telescope for only $99!
See ad on page 7 for details!

6", 8", and 10" LXD55-Series Schmidt-Newtonians with Autostar

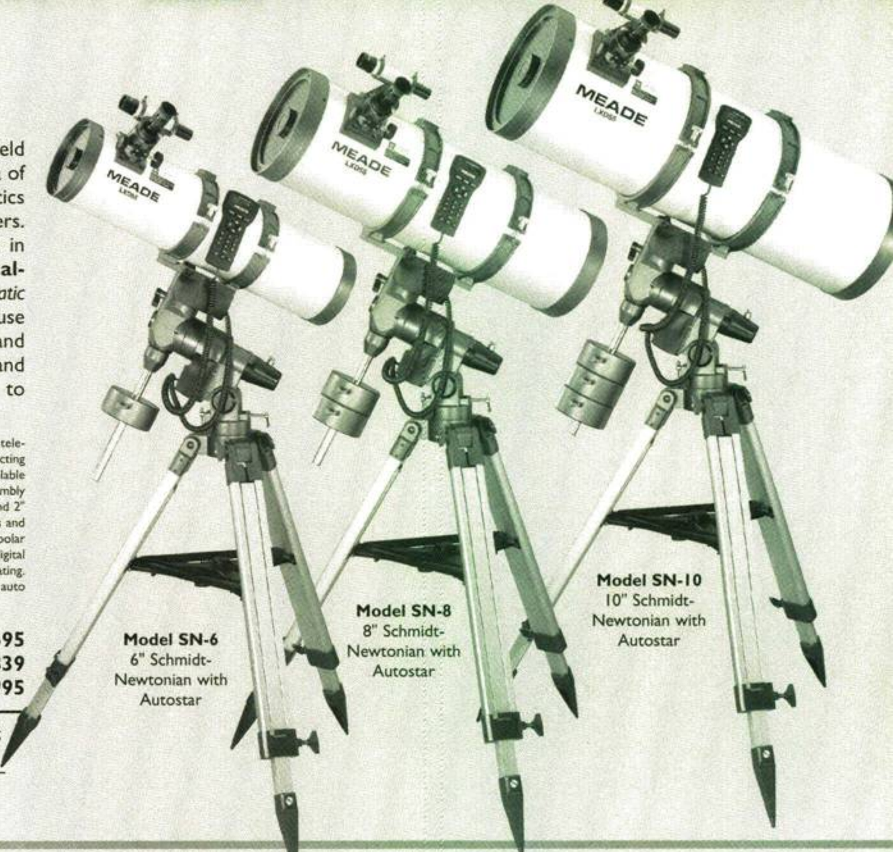
Meade American-made diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios. Fast f/4 (8", 10") or f/5 (6") optics present brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser resolution. The standard-equipment **Autostar Dual-Axis Control System** permits an amazing range of operations: *automatic GO TO capability* at 4.5°/second to 30,223 database objects (galaxies; diffuse and planetary nebulae; star clusters; the complete Messier, Caldwell, IC, and NGC catalogs; double and variable stars; eight major planets; asteroids; and comets); *nine selectable slew and slow-motion speeds* from 1x sidereal to 4.5°/sec.; plus *automatic sidereal-rate tracking* in RA, and much more.

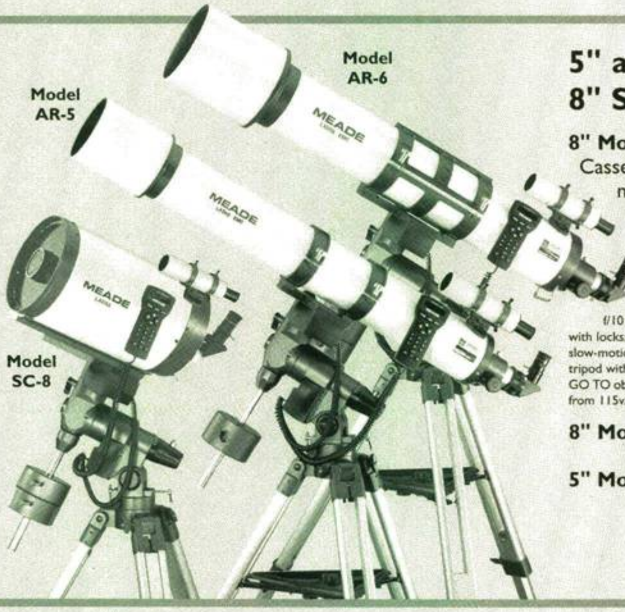
SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); white-enameled metal optical tube with machined-aluminum mirror cell; quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12v DC auto cigarette lighter plug or from 115v AC home outlet); operating instructions.

6" Model SN-6 Schmidt-Newtonian	**$695**
8" Model SN-8 Schmidt-Newtonian	**839**
10" Model SN-10 Schmidt-Newtonian	**995**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95.


MEADE
LXD55
Model SN-6
6" Schmidt-Newtonian with Autostar
Model SN-8
8" Schmidt-Newtonian with Autostar
Model SN-10
10" Schmidt-Newtonian with Autostar



5" and 6" LXD55-Series Achromatic Refractors and 8" Schmidt-Cassegrain with Autostar

8" Model SC-8: Includes the f/10 optical system of the Meade 8" LX200GPS for razor-sharp Schmidt-Cassegrain photo-visual imaging of the Moon, planets, and deep-space. All the telescope required by many amateurs for a lifetime of serious observing. **5" Model AR-5, 6" Model AR-6:** Excellent optical performance from the classical 2-element achromat design, with images rich in resolution and contrast and a minimum of chromatic aberration. Models SC-8, AR-5, and AR-6 allow for the full range of Autostar functions described above.

SPECIFICATIONS: Models SC-8 Schmidt-Cassegrain and AR-5 and AR-6 Achromatic Refractors — Each complete telescope includes 8" f/10 Schmidt-Cassegrain with MgF_2/standard coatings or 5" f/9 or 6" f/8 achromatic refractor with EMC super multi-coatings; quick-attach cradle ring assembly with locks; 8 x 50mm viewfinder; Series 4000 Super Plössl 26mm eyepiece; diagonal prism. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

8" Model SC-8 Schmidt-Cassegrain . . $1195
UHTC group for Model SC-8 — $175
5" Model AR-5 Achromatic Refractor . . 695

6" Model AR-6 Achromatic Refractor . . 895

Packing & shipping charges in the 48 states: 8" – $85; 5" – $85; 6" – $95.

6" and 8" LXD55-Series Schmidt-Newtonians and 5" Achromatic Refractor with Electronic Controller

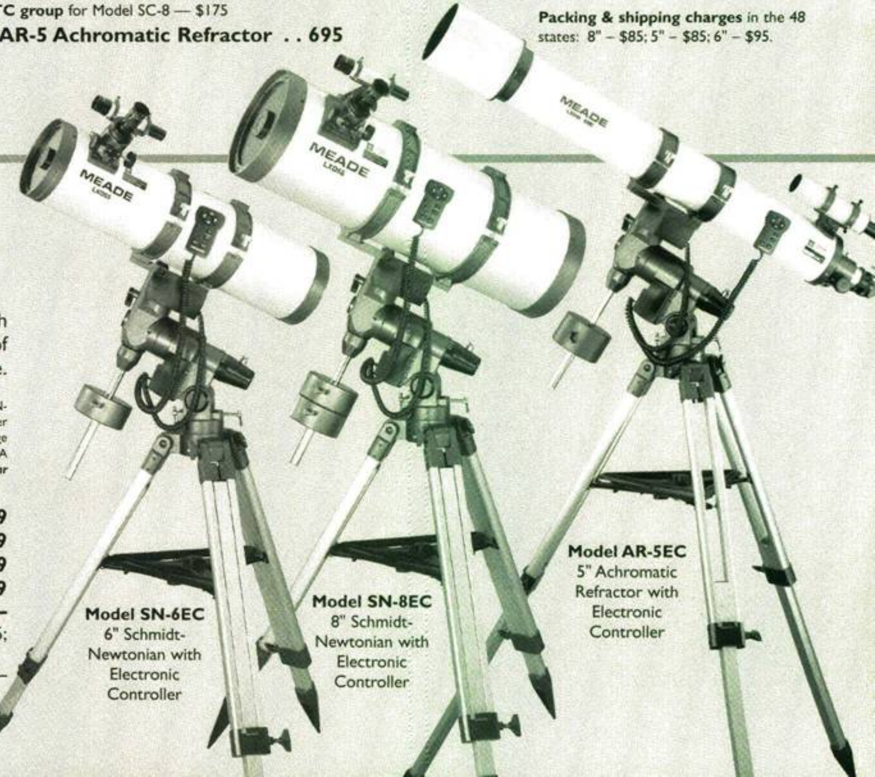
All the performance and features of the Autostar models above, but with 4-speed (2x, 8x, 32x, 4.5°/sec.) dual-axis Electronic Controller in place of Autostar. Upgrade to the Autostar Controller, available separately, at any time.

SPECIFICATIONS: Models SN-6EC, SN-8EC, and AR-5EC — Identical in every detail to the respective Models SN-6, SN-8, and AR-5, above, but with Electronic Controller (EC) in place of Autostar Hand Controller. Electronic Controller includes four dual-axis slewing speeds: 2x for photoguiding; 8x for image centering in the main telescope; 32x for image centering in the viewfinder; 4.5°/second for rapid-slew of the telescope across the sky; plus automatic sidereal-rate RA tracking. ***#497 Autostar Controller may be added at any time in the future and permits the full range of Autostar functions, including automatic GO TO, as described for Autostar-equipped telescopes, above.***

6" Model SN-6EC Schmidt-Newtonian	**$579**
8" Model SN-8EC Schmidt-Newtonian	**699**
5" Model AR-5EC Achromatic Refractor	**579**
#497 Autostar Controller, for any EC-model above	**149**

Ultra-High Transmission Coatings (UHTC) group: 6" Model SN-6EC – $85; 8" Model SN-8EC – $125.

Packing & shipping charges in the 48 states: 6" SN-6EC – $75; 8" SN-8EC – $85; 5" AR-5EC – $85. All prices shown in this ad are suggested U.S. national mail-order retail prices. © 2003


MEADE
LXD55
Model SN-6EC
6" Schmidt-Newtonian with Electronic Controller
Model SN-8EC
8" Schmidt-Newtonian with Electronic Controller
Model AR-5EC
5" Achromatic Refractor with Electronic Controller

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or studying tenuous nebulosity in deep-space, Meade SP's deliver unmatched contrast and image sharpness. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$79.95** (4.54)

32mm (52°); **40mm** (44°) each: **99.95** (5.26)

56mm (52°; 2") **199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Clearance Sale!

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (*far right in photo*), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$29.95** (3.86); **40mm $39.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A **49.95** (4.54)

Set #2–4 filters: #11, #25A, #47, #82A **49.95** (4.54)

Set #3–4 filters: #8, #21, #38A, #56 **49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia. **79.95** (4.54)

#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)

#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)

#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)

#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

New! 2" Diagonal Mirrors with UHTC

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. ***#930:*** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$119.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser:
Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser:
For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to *less than one second.* A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

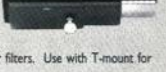
$79.95 (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.

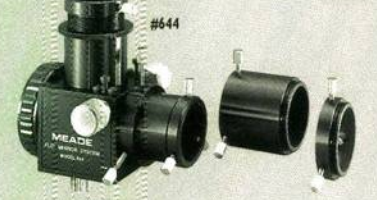
$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces.

249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)

15.00 (3.86)



#644

#647

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

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Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

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For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

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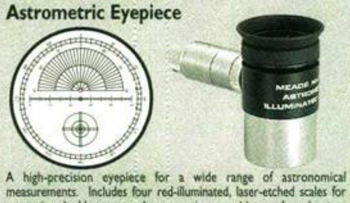

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#1247 Electric Focuser for ETX-125 models: **$119.95** (6.85)

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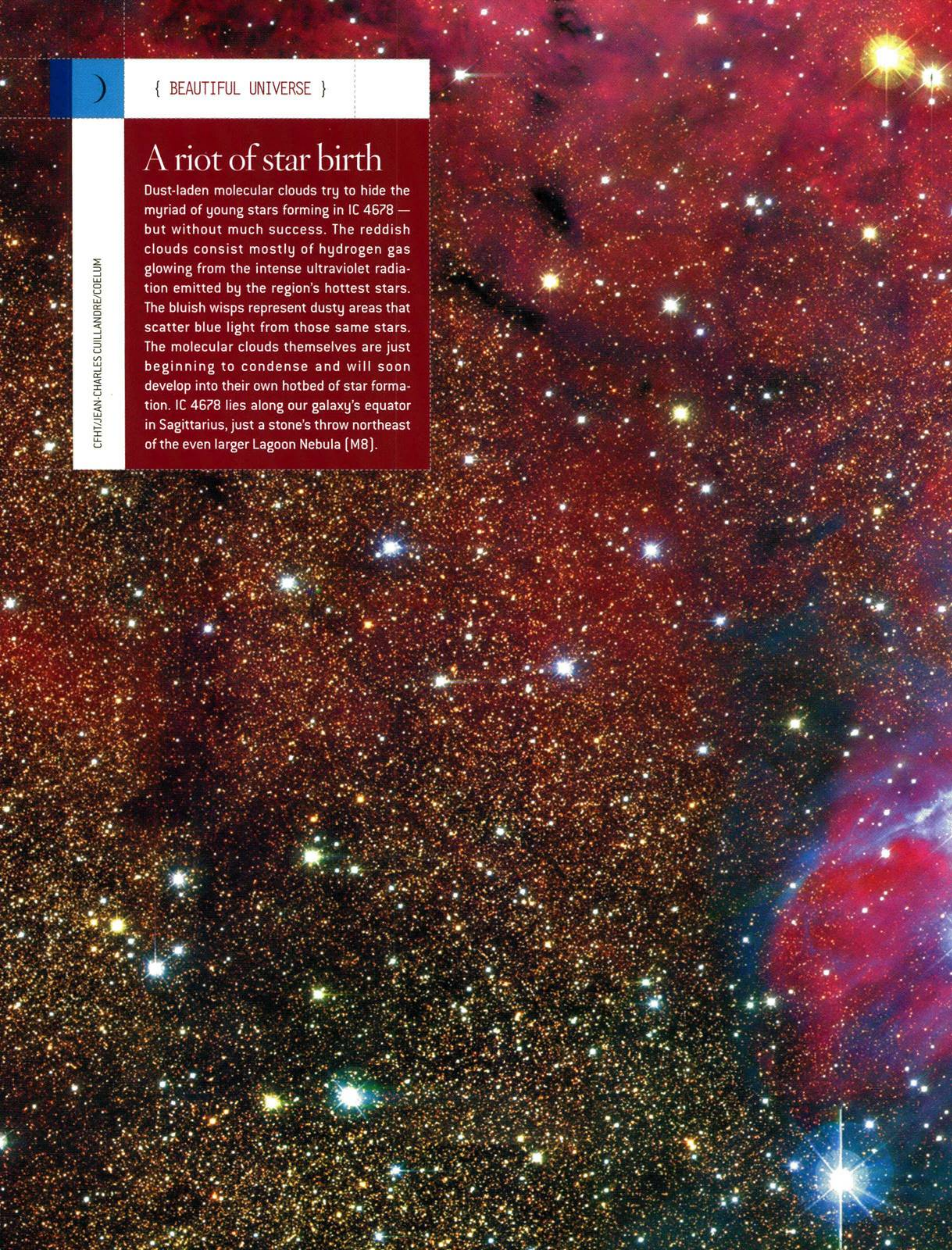

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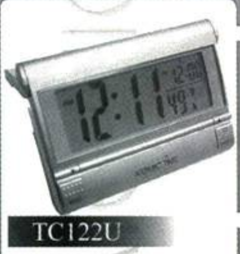

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The new *Astronomy*

Congratulations on the new, expanded *Astronomy*. I've been a subscriber for several years, and I really enjoyed the new look and content of the March issue. The magazine is more attractive and easier to navigate. *Astronomy* is better than ever. — **WASHINGTON L. C. LIMA,** TEREZINA, PIAUI, BRAZIL

THE UPDATED *ASTRONOMY* includes even more deep-sky photography, such as this beautiful image of The Pleiades (M45). Bobby Middleton used a 10-inch Takahashi Ritchey-Chrétien scope and Kodak 200 film to create this composite image. BOBBY MIDDLETON

The new magazine is awesome. While I usually do not believe it when something is advertised as "new and improved," you have proved me wrong. The new style includes everything that was promised — understandable science coverage, improved pictures and star charts, more reviews, and greater hobby coverage. I congratulate the staff of *Astronomy* for making a good magazine even better.
— **STEVE FISHER,** WEST VALLEY CITY, UTAH

I am extremely pleased at both the new look and the superb contents of the new *Astronomy*. I recently received my first telescope, and the expanded section for beginners is especially helpful and exciting. The expanded equipment review section is also a welcome addition. For those of us who don't know a lot about equipment, these reviews are terrific. I also look forward to reviews covering equipment for beginners.

It's also rewarding to see Bob Berman's column moved to the front of the magazine, instead of hidden in the back. I know this is the first thing many readers turn to in the magazine.

Kudos to the editorial staff. I will look forward even more to receiving my copy of *Astronomy* every month. — **LAWRENCE CHECKETT,** ST. LOUIS, MISSOURI

Big Bang vs. evolution

Dean Poll's comments concerning the Big Bang and evolution theory ("Letters," March) needs some clarification. His characterization of biological evolution as "19th- century subjective science that becomes increasingly discreditable with each new scientific discovery" doesn't hold up in light of the trail of evidence discovered in the last one and a half centuries.

Even as evidence mounted for the validity of Big Bang cosmology, the proponents of the Steady State theory at least grounded their theories in real scientific methodology. There is no scientifically valid alternative to evolution — only a theological/philosophical construct that replaces evidence with argumentation. Science is much more than an "Easter-egg hunt" for nothing but the facts; it's a method of thinking and working that requires honesty above all.
— **ROB KING,** PORTLAND, OREGON

Thank you for printing the letter by Dean Poll concerning the Big Bang and Darwinism. Many of us science folks agree with this view — that the Big Bang theory is alive and well, while Darwinism does not hold true — although I rarely see it put as succinctly as Poll put it. And I applaud you for printing something that goes contrary to the status quo.
— **MARK RITTER,** MURRIETA, CALIFORNIA

Correction

I enjoy *Astronomy* very much and found Peter Thomas's "Mysteries of the martian poles" (March) quite interesting. However, I would like to point out one correction. Thomas wrote that three men accompanied Roald Amundsen on his expedition to the South Pole in 1911, but it was actually four men: Sverre Hassel, Helmer Hanssen, Oscar Wisting, and Olav Bjaaland. — **PAMILLA SMITH,** EVANSTON, WYOMING

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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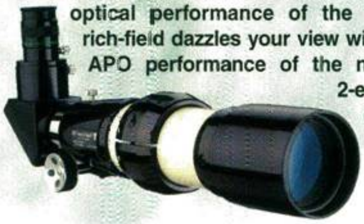

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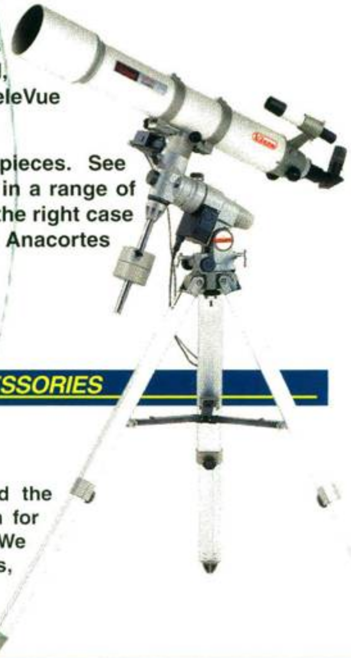

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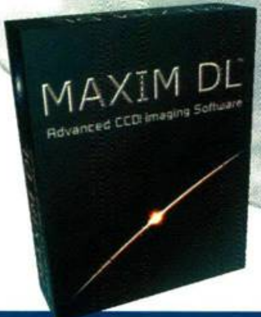

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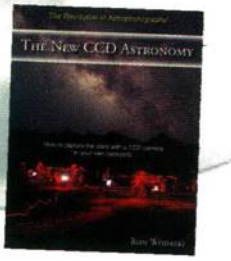

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BY WILLIAM SCHOMAKER

Vera Rubin

Few individuals — celebrity, politician, or scientist — have tasted personal and professional success as sweet as Vera Rubin has. An astronomer with the Carnegie Institution of Washington since 1965, and with more than half a century of eye-on-the-sky experience, Rubin is the recipient of countless scientific prizes and accolades. She was the first woman to be granted observing time on the historic 200-inch Hale telescope at Palomar Observatory. She's also the proud mother of four children who've all gone on to pursue their own careers in science.

When it comes to making her mark on world history, however, it's Rubin's eagerness to embark on solo journeys and to probe the shadows of understanding that has made all the difference. She single-handedly put dark matter on solid footing with her early investigations of galaxy dynamics — research that also revealed large-scale structure and bulk motions of the universe.

So just how deep does your affinity for astronomy run?

As a youngster, I was interested in celestial things — the Sun, the Moon, and the stars. At about twelve years old, I had a clear view of the Northern sky from my bed. I was captivated by the motion of stars about the Pole Star, and watching the stars throughout the night at times became more important than sleeping. In high school, all term papers I wrote were related to astronomy, whether in science, mathematics, history, or literature. Eclipses, comets, aurorae, and alignments of planets became important events in my life — as they still are. Walking home from my office in Washington, D.C., on the days of the equinoxes, I still watch the Sun set directly in line with an east-west oriented street.

VERA RUBIN, seen here at Kitt Peak in Arizona, has spent the last 40 years studying that which cannot be seen — dark matter. JACK PARSONS

How were you drawn to study galaxy dynamics — work that ultimately led you to discover dark matter?

As a young assistant professor at Georgetown University, teaching a class in statistical astronomy, I devised a problem for the class: Deduce the rotational properties of the outer regions of our galaxy from catalogs of stellar motions. In large measure, the problem was chosen to avoid conflicting with work of other astronomers. At the time, studying stellar motions near the centers of galaxies was a prominent field of research.

When it became clear that the available data was only the first step in learning about our galaxy's rotation, I started observing at Kitt Peak National Observatory and at Palomar. My goal was to find distant stars in the plane of the Milky Way and determine their velocities.

In no way did I suspect that I would still be observing galaxy dynamics 37 years later, or that the study of galaxy rotations would offer convincing evidence that most of the matter in the universe is dark.

Do you find it ironic that dark matter has become such a popular topic?

As an optical astronomer, I find it both ironic and funny that I am trying to study something we cannot see.

What will it take for astronomers to finally understand the overwhelming, yet dark, majority of the universe?

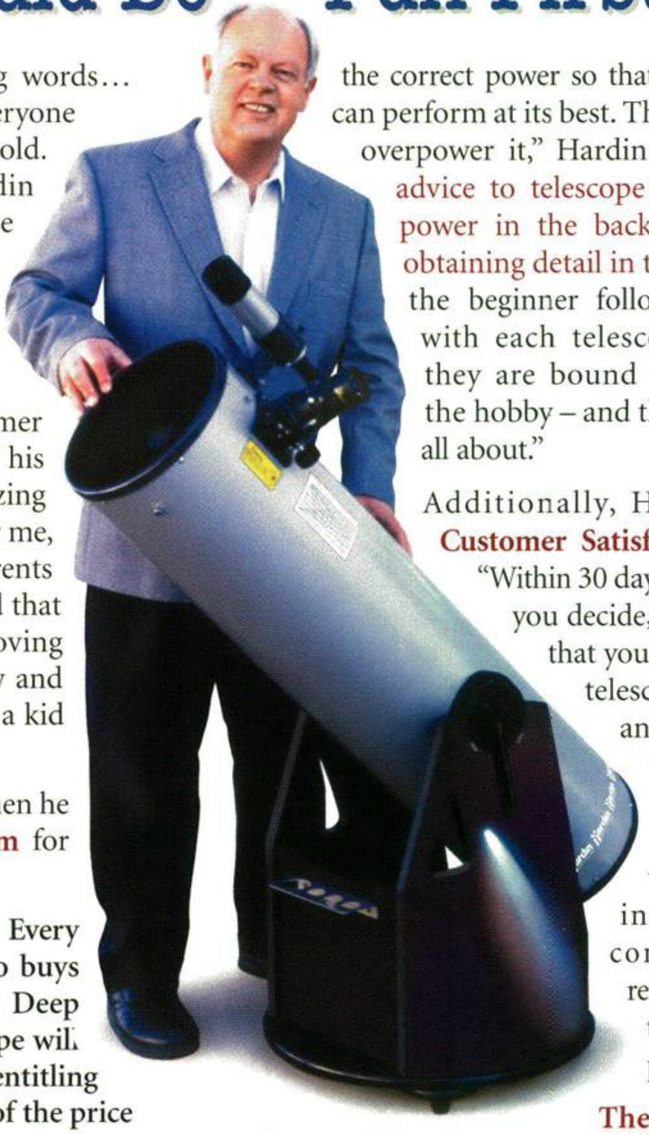
I wish I knew. If we had the answer to this question, we would probably also know what the darkness really is. And any further understanding of dark matter will depend on what that answer is. It could come from experiments in particle physics. It could come from theoretical studies that change our understanding of how gravity acts across exceedingly vast distances. While this may seem unlikely, quantum physics, which describes interactions on very small scales, also must have seemed unlikely in 1890.

How does the universe excite you and surprise you today?

There is so much that we do not know. Copernicus displaced us from the center of the solar system. Shapley displaced us from the center of the galaxy. And dark matter teaches us that atoms and molecules are not the major constituent of the universe. Our descendants may learn that there are hidden dimensions, or that ours is not the only universe. But even then there will be more to learn.

Astronomy has an exciting, perhaps endless, future.

Telescopes Should Be Fun First...



Larry Hardin is known for not mincing words... especially when it comes to telescopes. "Everyone should have a telescope...even a five-year-old. You can never start too young," Hardin emphasizes. "The problem is, most telescope makers scare off beginners by emphasizing the science more than the fun. Amateur astronomy should be fun first; the science will come as the enthusiasm grows."

Larry Hardin has been an amateur astronomer and professional telescope maker most of his life. "When I was a kid, I remember agonizing over which scope would be my next one. For me, it was a huge investment requiring my parents to pitch in," he explains. "Then I discovered that telescope makers were constantly improving their models and I always wanted the new and larger versions. It was like that when I was a kid ... and it's like that today."

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Using a telescope is more art than science. Part of that art is choosing the correct power so that your telescope can perform at its best. That means don't overpower it," Hardin cautions. "My advice to telescope buyers is: Put power in the back seat and put obtaining detail in the front seat. If the beginner follows this advice with each telescope they buy, they are bound to truly enjoy the hobby – and that's what we're all about."

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BY BOB BERMAN

Astronomy from a car?

Nights are now so short, it's fun to expand our passion into the sunny hours. Everyday events can demonstrate how things work across the universe, and such daytime physics can be exciting to kids, spouses, friends, anyone. Astro-related science observations can even happen when stuck in a car while driving somewhere. I'll prove it.

If the air conditioner's on, is the outside of the windshield fogging up? This means the dew point is higher than the car's inside temperature, indicating high humidity. Moisture on exterior glass is typical in southeastern states but uncommon elsewhere. Bad news: It's a sticky day. If it's clear, the sky is white, not blue. Tonight's observing will be good for Jupiter and the Moon but little else.

If it is raining, see how the drops seem to emanate from a single spot ahead of you. That radiating point rises and falls when you brake or accelerate. This effect is aberration, and it also applies to starlight. The universe's objects appear falsely shifted in front of us because of Earth's orbital motion. The change is only 20 arcseconds at max, the size of a grapefruit a mile away. The faster you go, the more things shift. At nearly light-speed, all galaxies and stars would become a single dazzling ball straight ahead, with blackness out all the other windows.

If the sky's clear and you're stopped at a light, check out any thin white clouds near the Sun. Through sunglasses, these often contain dramatic pinks, aquas, purples — a vivid phenomenon called "cloud iridescence." The crest of one lightwave coincides with the trough of another, canceling out the light entirely. Removing a major color destroys the mix that makes a cloud white. The remaining waves create new colors not part of the normal rainbow hues emitted by the Sun. You'll never see these colors anywhere in space, even through a spectroscope.

On the ground, such destructive interference makes those oily roadside puddles exhibit colorful swirls of psychedelic designs. It's all proof that light is a wave and not acting like a particle, since particles can't interfere in this way. Some couples get into horrible heated arguments over whether light is a wave or a particle. It's a major cause of divorce. But right here, out the window, wave advocates can momentarily get the last laugh.

At the next stoplight, try another project: Notice how metals (like the bumpers of trucks) gleam. Interesting process: Metals' outer electrons can absorb and then re-emit photons of light, while their inner electrons have too little flexibility to vibrate and give off light. Result: Sunlight hitting metals is not absorbed (like planet surfaces), nor does the light pass through (like the glassy lunar surface grains that help make the Full Moon so bright). Instead, light reflected from just their outer electrons makes metals neither transparent nor dull, but something else: gleamy.

Next stop, look for the Moon. During one week each month you'll easily see it in the morning sky. It will never be full and will always be lit up on the left side. This is the waning Moon. When it is a half-Moon or nearly so, it lies in front of us as Earth and Moon orbit the Sun. Look its way and you're facing forward as our planet hurtles through space. Cool stuff. When the morning Moon's in front of you, you're going 66,000 miles per hour over the speed limit.

On a broiling June day, you'll likely see mirages on the road — pools of water that are not there. Hot air over the asphalt makes light increase its speed compared with cooler, denser air a few inches higher up. When light changes speed it bends, or refracts. Starlight hitting air of disparate temperatures refracts, too. Result: twinkling.

On the car radio, FM stations fade in and out near hills or buildings. But AM signals are much steadier. This is the bending of electromagnetic radiation around obstacles, called diffraction. The longer AM waves diffract more readily than the FM band. Diffraction of light causes blurriness through telescopes, and you can make diffraction rings visible by simply putting a star out of focus.

Next, roll down the window and watch as all your important loose papers get sucked out. This is a result of Bernoulli's principle. Your car's motion has produced a stream of rapidly moving air outside. Fast-moving gas means low pressure, which creates enough of a vacuum to pull out the documents.

Rotate your sunglasses. Do sections of the sky turn darker? Do reflections on car windows vanish? Then your glasses are polarized. Reflections are everywhere in life. Unless you're looking right at the Sun (a no-no), all light has bounced off something, and this aligns their waves in a particular plane. Polarized lenses let mostly one plane through, magically "removing" reflections from objects. The half-Moon is vivid through sunglasses because that phase alone sits in the most polarized part of the sky.

You finally arrive. A friend says, "Hey, what's happening?" Normally you'd say, "Nothing much." But today you reply, "So far I've witnessed refraction, reflection, diffraction, polarization, aberration, destructive interference, Bernoulli's principle, and Earth's motion. . . . You?"

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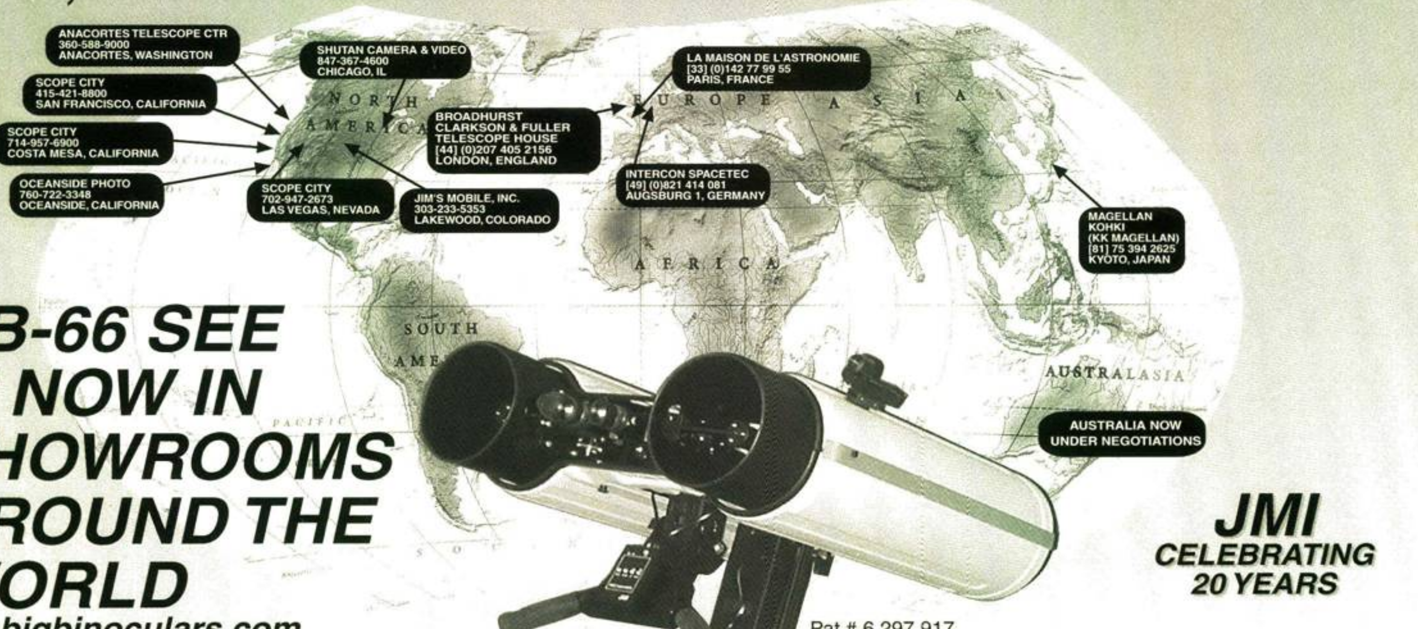
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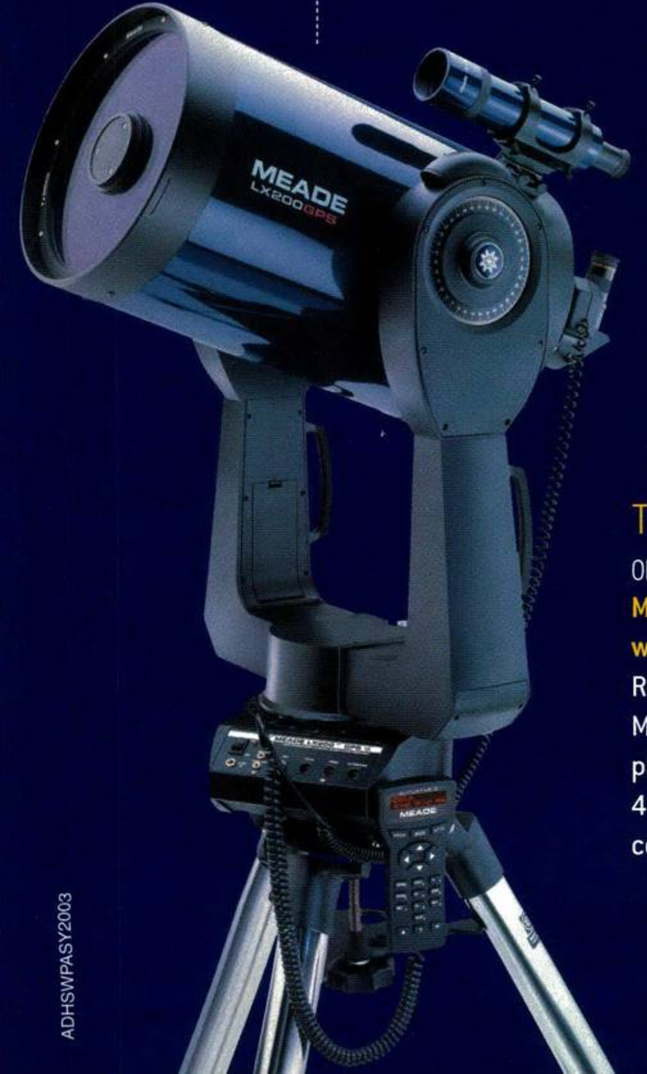

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No Purchase Necessary. The official start date for the *Astronomy* 30th Anniversary Sweepstakes is April 28, 2003. Official entry forms are bound in the June, July and August 2003 issues of *Astronomy*. The *Astronomy* 30th Anniversary Sweepstakes is open to residents of the United States and Canada (except Quebec) only, 18 years of age or older. Employees (and their dependants and immediate household members) of Kalmbach Publishing Co., their advertising and promotional agencies, and participating sponsors are not eligible to participate.

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Prizes and Odds of Winning. One drawing will be held on or about August 29, 2003, for the following awards: One Grand Prize consisting of a Meade 10" LX200GPS telescope (retail value $2,995.00). One First Prize consisting of a Meade 8" LX200GPS telescope (retail value $2,495.00). One Second Prize consisting of a Meade 8" LX90 telescope (retail value $1,695.00). One Third Prize consisting of a Meade ETX-125EC with Autostar telescope (retail value $895.00). One Fourth Prize consisting of a Meade ETX-90EC with Autostar telescope (retail value $495.00). One BONUS drawing will also be held on or about August 29, 2003, for the following awards: One First Prize consisting of a Dark Sky Panel Observatory System (retail value $600.00). One Second Prize consisting of a Telescope Carrying Case (retail value $500.00). One Third Prize consisting of a SkyQuest XT8 Dobsonian (retail value $449.00). One Fourth Prize consisting of an Astroscan Wide-Field Telescope with 2 Plossl Eyepieces (retail value $209.00). Five Fifth Prizes consisting of a Celestron Starter Kit (includes a Night Vision Flashlight, Moon Filter, 2x Barlow Lens, Car Battery Adapter and plastic carrying case lined with foam) (retail value $115.95). One Sixth Prize consisting of the Lunar Map Pro 1.5 software (retail value $89.95). One Seventh Prize consisting of a Space Shot poster set (retail value $79.95). One Eighth Prize consisting of the Lunar Map Pro – Basic edition software (retail value $39.95). Cash equivalents of merchandise will not be awarded. Substituting prizes is not allowed. Any applicable federal, state and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for *Astronomy* magazine is 160,226. Sweepstakes void in Quebec and void where prohibited.

Validation and Acceptance. Winners in the *Astronomy* 30th Anniversary Sweepstakes will be selected in a random drawing conducted by an independent judging organization whose decisions are final. Canadian prize awards subject to skill test requirement. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of the judging organization. Sweepstakes entries void if not legible, not completed in full, not obtained legitimately, or if forged, photocopied, mechanically reproduced, late or tampered with. The potential winners must sign and return an Affidavit of Eligibility, publicity release and Release of Liability within fourteen (14) days of notification. In the event of noncompliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late entries or notifications. All sweepstakes entries become the property of the sponsor and will not be returned.

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BY GLENN CHAPLE

Phase transitions

Teachers are often encouraged to begin a classroom lesson with some kind of thought activator — something to jump-start their students' brains. With that in mind, I've decided to get your cranial juices flowing by opening this month's column with an activator of our own:

Professor Chaple's pop multiple-choice astroquiz

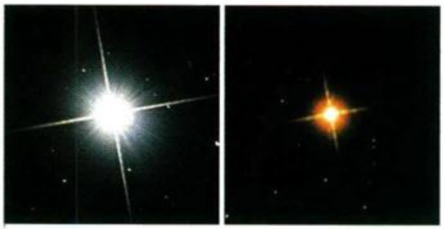
QUESTION: What color are stars?

A. White
B. Really white
C. Really, really white
D. Varies with the star's surface temperature, with the hottest stars appearing bluish-white to white, medium-temperature stars yellowish, and "cool" stars orange to red

The correct answer is (surprise, surprise!) letter D. If you picked one of the first three choices, be sure to read this column very carefully.

It's pretty easy to understand why most people would assume stars are white. If you read Bob Berman's column in the March issue, you know that the human eye isn't very sensitive to color emanating from faint light sources. Since most stars are rather feeble specks, they do seem white. But 1st-magnitude stars are a different story, shining brightly enough to betray their true colors.

A good example is Arcturus. This star is easy to find using the Big Dipper as a guidepost. The three stars in the Dipper's "handle" arc away from the Dipper to a brilliant star shining high in the early evening sky. "Arc to Arcturus" — get it? Leader of a kite-shaped constellation called Boötes the Herdsman, Arcturus ranks fourth in brightness among all nighttime stars. Arcturus has a diameter two dozen times greater than our Sun. But the star's striking golden-yellow color really impresses beginners.



ARCTURUS, (left) the Bear Guardian, is the brightest star in the constellation Boötes and ranks fourth in the brightness of nighttime stars. **ANTARES,** (right) the Heart of the Scorpion, is in an advanced stage of evolution, nearing the end of its life. JOHN CHUMACK

Star colors are a function of their surface temperatures. At one end of the temperature spectrum are the hottest stars, which appear white to bluish-white. At the other end are the "cool" reddish stars. Arcturus is an in-between yellow-orange star. Astronomers categorize stars by spectral class, which is a function of their surface temperatures. Arcturus belongs to spectral class K — a group comprised of orange-hued stars slightly cooler than our Sun, a yellowish G-type star with a surface temperature of 5,500 K (10,000° F).

Did you know that Arcturus played a key role in opening the Chicago World's Fair of 1933? Light from this star passed through a telescope and was collected on a photoelectric cell that converted starlight into the electricity that turned on the lights to the grounds. Neat, eh? This was 70 years ago. And you thought Granny lived in the Dark Ages!

The same arc that brought us to Arcturus continues southward to another 1st-magnitude star — Spica, located in the constellation Virgo the Virgin. ("Arc to Arcturus, Speed to Spica." Pretty catchy, isn't it?) Spica's color is what stars are "supposed" to be — white. Spica's surface temperature is about 25,000 K (45,000° F). Compare Arcturus and Spica, and you'll definitely notice the color contrast. Spica seems dimmer than Arcturus, but don't be fooled. Spica is 260 light-years away, seven times more distant than Arcturus. If next to Arcturus, Spica would shine a dozen times brighter.

Completing our trio of stellar gems is Antares, the "heart" of Scorpius the Scorpion. Antares is derived from the Greek *anti-ares*, which means "rival of Mars" — an obvious reference to this star's distinctive red hue. To find Antares, start at Spica and look to the left (eastward) along the southern horizon until you come to a bright reddish star (the all-sky map in the centerpiece shows the location of all three featured stars). Antares is a huge, bloated star in its final stages of life. This cosmic colossus, 330 light-years away, boasts a diameter of about 200 million miles — equal to 240 of our Suns laid end-to-end. But "big" doesn't necessarily mean "hot." Red stars are among the coolest in the Galaxy — if we call 3,500 K (5,800° F) "cool."

On the next clear June evening, go outside and pay a visit to these three fascinating stars. And if you failed my little astroquiz, return to the top of the page and try again.

Next month: Get ready to "see double." Clear skies!

Questions? Comments? Write to me in care of *Astronomy* or e-mail me at gchaple@astronomy.com (if you'd like your message shared with the staff of *Astronomy* before they relay it on to me). If you prefer to contact me directly, e-mail me at gchaple@hotmail.com.

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NSF AND ESO finalized an agreement to jointly construct and operate the Atacama Large Millimeter Array in Chile. This February 25, 2003 pact gives the green light to what will become the world's largest and most powerful radio array.

news 06

Read all about it: Coronal mass ejections, China aims men at space, Pioneer falls silent, Dumbbell re-viewed, and the Lagrangian points for satellites.

COSMOLOGY

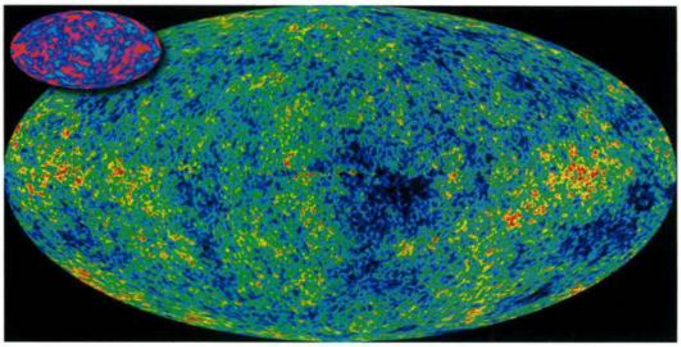
Happy 1.4 x 10^{10}th birthday

After a year-long "exposure," NASA has released the most detailed "baby picture" of our universe ever taken. The cosmic portrait taken by the Wilkinson Microwave Anisotropy Probe (WMAP) pegs the age of the universe at 13.7 billion years old. The WMAP results have a remarkably small one-percent margin of error — five times less than recent Hubble Space Telescope observations of white dwarfs that showed the universe to be somewhere between 13 and 14 billion years old.

27 The Boomerang Nebula
28 Comet C/2002 V1 (NEAT) in SOHO's view
30 Ride and Tereshkova: 20 and 40 years later
31 Molecular cloud beats like a tell-tale heart

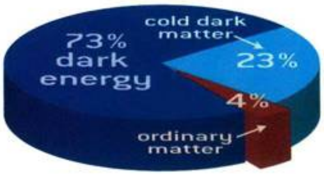
WMAP, which is the successor to the Cosmic Background Microwave Explorer (COBE), measures extremely high-energy radiation emitted from the Big Bang. Over 14 billion years, the wavelength of the radiation has stretched into the microwave spectrum and has cooled to an average temperature of 2.73° above absolute zero. The tiny patterns in the millionth of a degree temperature fluctuations — 380,000 years after the Big Bang — are the seeds of what later became galaxy clusters and the large-scale structures we observe today. In addition to telling us the age of the universe, the data also show:

- Inflation and Big Bang theories continue to ring true. The composition of the universe is made up of 4 percent "normal" baryonic matter (atoms that compose all we are currently able to observe), 23 percent cold dark matter, and 73 percent dark energy. Dark energy is the "anti-gravity" force that keeps the universe accelerating.



THE WILKINSON MICROWAVE ANISOTROPY PROBE has 33 times better spatial resolution and 45 times more sensitivity than its predecessor, COBE (data shown at upper left), in measuring the cosmic microwave background, which averages a chilly 2.73° above absolute zero. Red indicates warm areas, while blue shows cooler regions. NASA

- The geometry of the universe is "flat" — as opposed to being "open" or "closed" — so all the Euclidian geometry exercises we struggled with in school apply on enormously large scales as well as they do on a sheet of paper.



ONLY 4 PERCENT of the universe is made up of ordinary matter. Some 23 percent is cold dark matter, and 73 percent is thought to be dark energy — an anti-gravitational force — that is accelerating the rate at which the universe expands.

- The first generation of stars to bring light to the young, dark universe ignited only 200 million years after the Big Bang, much earlier than scientists expected.

WMAP was named in honor of David Wilkinson, a world-renowned cosmologist and team member who died last September. Launched on June 30, 2001, WMAP resides at the second Lagrangian point, or "L2," and will continue to study the cosmic microwave background for another three years. WMAP team member David Spergel says, "This is the beginning of a new stage in our study of the universe." — **TOM FORD**

THE LARGEST QWIP (Quantum Well Infrared Photodetector) array has been fabricated by a NASA-led team. This one million-pixel detector promises a low-cost alternative to conventional infrared detectors.

PLANETARY NEBULA

Boomerang's new look

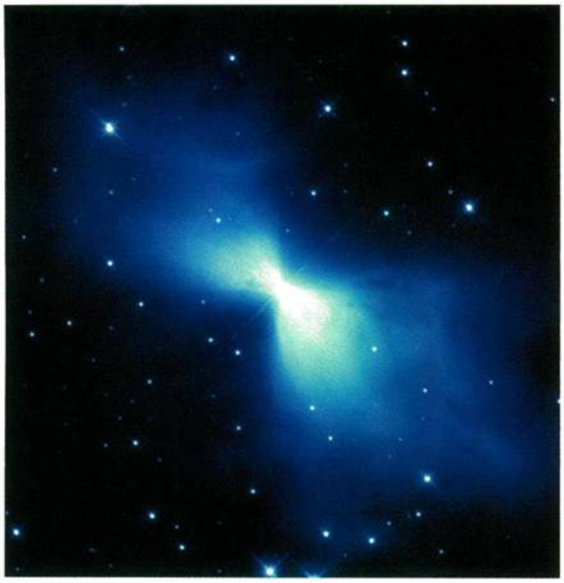
The coolest place in the universe has no cover charge and no bouncer at the door. But you'll have to wear a tie to get in — a bow tie, that is.

In this image of the Boomerang Nebula, Hubble's eye reveals two distinct lobes — loops of a neat bow tie. This nebula is located 5,000 light-years from Earth in the constellation Centaurus. This image demonstrates how Hubble's keen vision can reveal surprises even in known celestial objects.

In 1980, observers in Australia dubbed the young planetary nebula the Boomerang Nebula. Using low-resolution equipment, they saw only a slight curvature in the nebula's lobes, suggesting a boomerang shape. The Boomerang's peculiar shape may result from 500,000 kilometer-per-hour winds blowing off the nebula's central dying star. The star's rapid loss of mass, up to 0.001 of a solar mass annually, has caused the nebula to expand and cool quickly, making it the coldest region in the known universe.

In 1995, astronomers measured the Boomerang's temperature at –272° C, only one degree above absolute zero and two degrees colder than the background glow of the Big Bang. It is the only known object colder than the cosmic background radiation.

— LAURA WILLIAMS



BRIGHT STARLIGHT from the Boomerang's central star reveals ghostly arcs and filaments. At –272° C, the Boomerang Nebula is the coolest place observed in the known universe. HST/ESA/NASA

INSTRUMENTATION

Flexible focus

The 6.5-meter Multiple Mirror Telescope in Arizona has a new secondary mirror that will help it obtain ever-sharper views of the universe. About 64 centimeters across and less than two millimeters thick, the mirror continually changes shape to compensate for blurring effects caused by Earth's atmosphere.

A FLEXIBLE SECONDARY provides the MMT with ultra-sharp images. ESO

The MMT's built-in adaptive optics uses a camera to observe atmospheric turbulence. A computer behind the secondary mirror uses 336 actuators to reshape the mirror in response to the camera's images. This refocuses the incoming light before it reaches the telescope's focus.

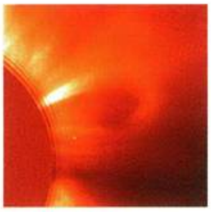
— VANESSA THOMAS

THE SUN

Solar ejections

New clues to understanding violent explosions on the Sun have been discovered by solar physicists at the Mullard Space Science Laboratory. These explosions, called coronal mass ejections (CMEs), originate in active regions on the Sun that contain plasma loops. Most of the loops studied were approximately 30,000 miles (48,000 km) long. However, giant loops, up to 300,000 miles (480,000 km) long, were detected as well.

Previously, it was believed that giant loops were rare and never exploded, but recent studies of satellite data have shown this not to be the case.



A GIANT LOOP erupts as a coronal mass ejection. ESA/NASA

In fact, the larger a loop is, the more likely it is to explode, creating a CME.

Alexi Glover, part of the space weather team at the European Space Agency, explains, "These huge loops have been observed for many years — but their connection with CMEs is only just being understood. In the future we hope to be able to predict CMEs before they take place, and step by step we are heading toward that goal."

— MICHAEL E. BAKICH

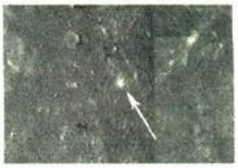
THE MOON

Forensic astronomy

On November 15, 1953, amateur astronomer Leon Stuart photographed what he believed was the aftermath of an explosion on the Moon. This image documents a flash in front of the Moon's face. Scientists think they have now found a crater formed at the moment of Stuart's photo.

"Stuart's remarkable photograph of the collision gave us an excellent starting point in our search," says Bonnie J. Buratti of JPL. "[We] estimated the object that hit the Moon was approximately 20 m (65.6 ft) across, and the resulting crater would be in the range of one to two km (0.62 to 1.24 mi) across. We were looking for fresh craters with a non-eroded appearance."

Buratti and colleague Lane Johnson from Pomona College found just such a crater using Clementine satellite data.



STUART'S CRATER was identified in Clementine images. NASA/JPL

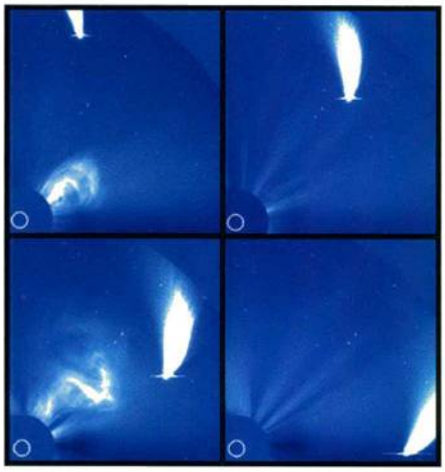
While Stuart passed away in 1968, his son Jerry Stuart offered these words: "Astronomy is all about investigation and discovery. It was my father's passion, and I know he would be quite pleased."

— PAMELA L. GAY

THE SOLAR SYSTEM

NEAT online view

Although Comet C/2002 V1 (NEAT) disappeared from view to earthbound observers on February 11, it remained in the sights of the orbiting Solar and Heliospheric Observatory (SOHO) between February 16 and 20. Astronomers were able to track NEAT's progress through the satellite's website, sohowww.nascom.nasa.gov/.



C/2002 V1 (NEAT) flew past the Sun under the watchful eye of the Solar and Heliospheric Observatory (SOHO) satellite. SOHO/LASCO (ESA & NASA)

SOHO is a European Space Agency and NASA spacecraft designed to study the Sun's interior, outer atmosphere, and solar winds. It constantly monitors solar activity and space weather events.

Thanks to SOHO's Large Angle and Spectrometric Coronagraph (LASCO), website visitors were able to view the comet's progress as it traversed the typically blinding realm of the Sun.

LASCO's technology simulates a total eclipse. Obscuring the Sun's bright glare, it focuses on the Sun's outer atmosphere. Coincidentally, this same technology provides the satellite a unique view of comets.

NEAT brightened as it neared the Sun, becoming the brightest comet ever observed by LASCO. Be sure to access SOHO's website for many more stunning solar images. — **MATT QUANDT**

China aims men at space

With the successful conclusion of the fourth unmanned test of the Shenzhou spacecraft, China is on the verge of sending astronauts into space by year's end. This will make China the third nation, after Russia and the United States, to accomplish this feat, although representatives of almost 30 other nations have flown into orbit aboard Russian and U.S. vehicles.

The 18,000-lb Shenzhou space vehicle bears a striking similarity to Russia's Soyuz design. A rounded conical command module is fastened between an aft-mounted service module containing a rocket engine, power, and other functions, and a forward-mounted orbital module with room for life support equipment and scientific apparatus. Only the command module and its two or three astronauts return to Earth.

The Chinese copied workable Russian designs for systems such as the launch escape tower (which pulls the cabin free in the event of a booster failure during launch) and the pressure suits (which are copied right down to the stitching pattern). But other hardware is based on Chinese experience with their own satellites. Both the propulsion system and solar panels have distinctive features that promise advantages over the 35-year-old Russian Soyuz designs.

The Chinese media has carried a flood of details about the project, including descriptions of the jet pilots who are training as astronauts. At least two, and perhaps three, men will be aboard Shenzhou-5 when the first manned flight lifts off later this year.

THE SHENZHOU CAPSULE is modeled from the Russian Soyuz on the outside, but inside has uniquely Chinese technology. HSINHUA NEWS AGENCY

CHINESE JET PILOTS TRAIN TO BE ASTRONAUTS as China prepares to launch the first manned Shenzhou vehicle. HSINHUA NEWS AGENCY

Two leading motivations justify this and other Chinese space programs. Foremost is the belief that by forcing the Chinese aerospace industry to achieve the reliability levels required for human space flight, it will also develop technological capabilities that can be applied to other civil and military projects. Second, a demonstration of human space flight capabilities will have profound domestic and international impact in areas such as trade, military deterrence, and pure national prestige. Additionally, practical technological applications derive from all space activities.

Far from merely repeating past Russian and U.S. experiences, China appears to be plotting an independent course for its specific needs. An operational Shenzhou vehicle will put China on par with existing Russian human space capabilities and will allow it to play a role in the International Space Station, if desired. More likely, China will pursue its own goal of a small space station in a different orbit, celebrating its arrival on the world stage as an essential equal to players with decades more experience. How successful this will turn out to be, and the expense and value of China's program, remains to be determined. — **JAMES OBERG**

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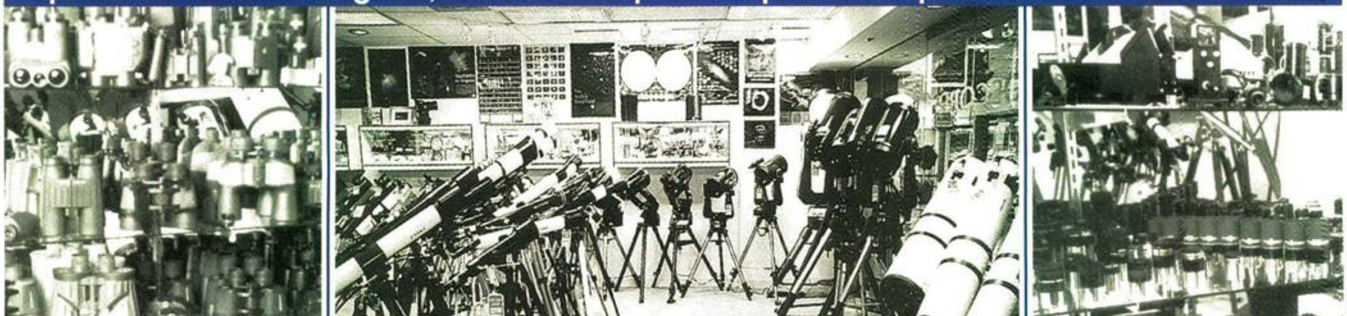

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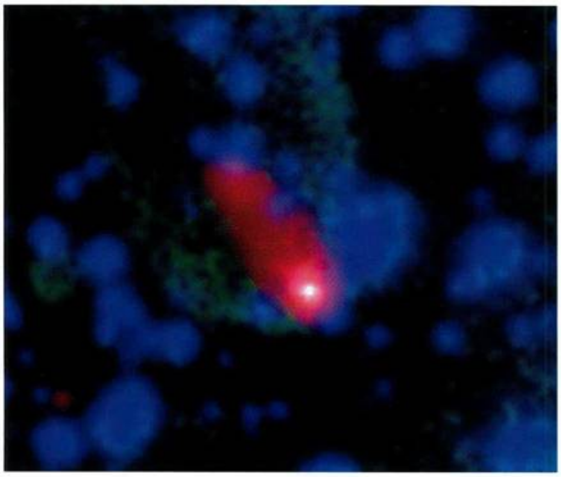
MAP BECAME WMAP when NASA renamed the Microwave Anisotropy Probe after Princeton professor David T. Wilkinson. This pioneering physicist and cosmologist died in September 2002. Wilkinson studied the Cosmic Microwave background for 38 years.

HIGH-ENERGY

Bite of the pulsar



SHOCKS WITHIN SHOCKS appear in this composite optical [green/blue] and x-ray [red/white] image of B1957+20. X-RAY: NASA/CXC/ASTRON/B. STAPPERS ET AL., OPTICAL: AAO/J. BLAND-HAWTHORN & H. JONES

The nearby pulsar B1957+20 has deadly habits. This long-dead star hungrily strips material from its companion star and transforms this infalling mass into angular momentum. Slowly growing in size and rotation rate, B1957+20 rotates in just 0.0016 second as it sweeps through the galaxy at almost a million kilometers per hour. This high velocity, combined with its high-energy wind, causes it to create a double shockwave as it moves through interstellar material.

"This is the first detection of a double-shock structure around a pulsar," says Benjamin Stappers of the Dutch Organization for Research in Astronomy (ASTRON). The outer, visible bow shock is created by the star's motion, and the inner bow shock is from the pulsar's high-energy wind.

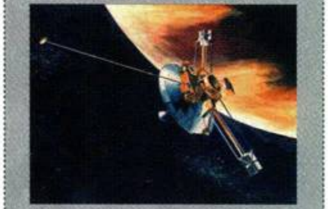
"This star has had an incredible journey. It was born in a supernova explosion as a young and energetic pulsar, but after a few million years grew old and slow and faded from view," says Bryan Gaensler of the CfA. "Over the next few hundred million years, this dead pulsar had material dumped on it by its companion, and the pulsar's magnetic field has been dramatically reduced.

"This pulsar has been through hell, yet somehow it's still able to generate high-energy particles just like its younger brethren," continues Gaensler. This Chandra result confirms that even a relatively weakly magnetized neutron star can generate intense electromagnetic forces and create a pulsar wind if it is rotating rapidly enough. — **P. L. G.**

SPACE PROBE

Explorer silenced

The well-traveled Pioneer 10 spacecraft glided out of radio contact at a mere 7.6 billion miles away on January 22, 2003. In an attempt to connect with the wandering space veteran, NASA failed to detect a signal on February 7, 2003.



AFTER THIRTY YEARS of dependable service, Pioneer 10 fell silent Feb. 7, 2003. NASA

When it launched on March 2, 1972, Pioneer 10 originally intended to last just 21 months.

Twenty-one months and about 23 years later, Pioneer 10 completed its science mission while drifting through the outer regions of the solar system on March 31, 1997. Since then NASA has tracked Pioneer 10's signal as part of a communication technology study. — M. Q.

NEBULAE

Hubble picks up a Dumbbell

Dust and gas in the Dumbbell Nebula create a glowing tribute to a dying star in this Hubble Space Telescope image. About 1,200 light-years away, the Dumbbell [M27] is the cast-off envelope of the elderly star at its center. Found by Charles Messier in 1764, it was the first planetary nebula discovered.

In the Hubble close-up, knots of glowing gas gather in a kind of cosmic expressway, streaking from one corner to another while other clumps are scattered about. The linear formation is part of the southwestern leg of the apple-core shape that lends M27 its popular name. The knots, of varying shapes and sizes, form when hot ionized gas from the central star slams into cold neutral gas, fragmenting the cloud. — **V. T.**

CLUMPS OF LUSTROUS GAS streak through this close-up of the Dumbbell Nebula. NASA AND THE HUBBLE HERITAGE TEAM [STScI/AURA]

WOMEN IN SPACE

Earth calling Seagull

June marks the 20th and 40th anniversaries of the first U.S. and Soviet women in space.

Valentina Tereshkova launched on Vostok 6 on June 16, 1963. Her flight lasted almost three days and orbited Earth 48 times. Her call sign "Chayka," or seagull, would stick with her for life. Soviet Premier Nikita Khrushchev insisted she marry cosmonaut Andrian Nikolayev to form his "space family."

Twenty years later, on June 18, 1983, American Sally K. Ride flew aboard the Space Shuttle Challenger (STS-007). She became the first American woman in space, logging over 350 hours in orbit during two shuttle missions.

— **KELLEY KNIGHT**

VALENTINA TERESHKOVA was the first woman to orbit Earth. AP

SALLY RIDE became the first American woman in space. NASA

MOLECULAR CLOUD

The tell-tale cloud

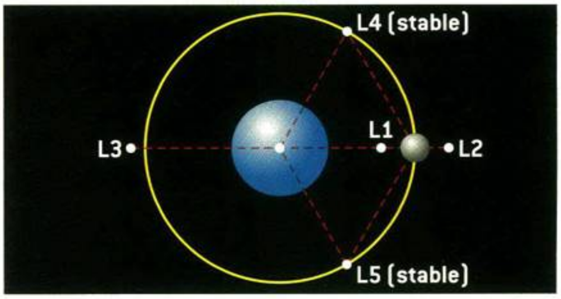
At first glance, Barnard 68 is a typical molecular cloud located 300 light-years away in the constellation Ophiuchus. At second glance, it is anything but typical. "We studied Barnard 68 to find out if it was rotating, expanding, or contracting," says Charles Lada of the CfA. "Instead, we found that this molecular cloud appears to have a heartbeat."

BEATEN BUT BEATING ON, the Bok globule Barnard 68 was shocked by a supernova explosion and now pulsates. ESO

Barnard 68 is a Bok globule of gas and dust that is chilled to a temperature of just 10° above absolute zero. Filling an area about 12,000 times larger than Earth's orbit around the Sun, it has a mass about 1.5 times greater than the Sun. In observations taken with the IRAM 30-meter radio telescope in Spain, Lada's team found signatures of both infalling and outflowing material at different locations across the face of the cloud. They believe this complex motion is the tell-tale echo of the death throes of a supernova explosion. Barnard 68 is located in a rarefied zone cleared out by a supernova's shockwave.

The supernova that shocked Barnard 68 may actually have stripped the cloud's outer layers, leaving behind a beating core. Although it does show pulsation modes, Barnard 68 is an otherwise stable molecular cloud. — **P. L. G.**

Home on Lagrange



LAGRANGIAN POINTS, shown here for the Earth/Moon system, can be found in all systems containing two objects with very different sizes. PAMELA L. GAY

It is often said that mathematics is the secret language of the universe. From the astronomical point of view, Lagrange and his "points" in space give a proof that is providing observational translations of the skies right before our eyes.

In the late 1700s, French mathematician Joseph Lagrange showed that in any system with one large and one smaller body co-orbiting each other, five relative locations exist where a third very small object could remain in orbit indefinitely. Three points run along a line through the two main bodies, and two lie at the third apexes of equilateral triangles that have the two main bodies at the other corners. Because these so-called "equilateral points" are stable — objects drifting near them tend to stay near them — natural debris tends to collect in them.

The linear points — L1 between the two bodies, L2 on the far side of the smaller body, and L3 on the far side of the larger body — are unstable. Objects near these points tend to drift away and eventually fall into a normal elliptical orbit around one of the two bodies. The only way an object can stay around these linear Lagrangian points is to steer themselves with occasional bursts of rocket power.

The most famous spacecraft now at a linear Lagrangian point (the Earth-Sun L1 point) is SOHO, the solar observer and comet catcher. The Genesis probe also lurks in this region, collecting solar wind particles to bring back to Earth next year. Also aimed for that point 1,500,000 km sunward of Earth is Triana, an Earth-watching probe that is still awaiting a launch opportunity.

Down-Sun from Earth is the Earth-Sun L2 point. The Wilkinson Microwave Anisotrophy Probe, WMAP, is now on station there, and the European Space Agency also has several projects in the works for this region.

"Constellation-X," NASA's next x-ray observatory, will also be deployed at the Earth-Sun L2 later this decade. It will employ several independent spacecraft whose observations will be combined much like those of a multi-mirror telescope on Earth.

As with ground-based multi-mirror telescopes, the precise spacing between independent units is critical to extracting the best data from the combined instrument. Constellation-X will be the first satellite cluster to exploit the relatively homogeneous gravitational field of a Lagrangian point. The differential forces on satellite clusters in conventional orbits would make a mission like this extremely difficult.

Other advantages, such as uniform solar heating, low background radiation, and reliable uninterrupted communications links, make the long trip up and out to these marvelous mathematical zones worthwhile. For more and more astronomical satellites, it will soon be: "Home, home on Lagrange." — **J. O.**

Advanced Series

C10-NGT
C10-N
C9 1/4-SGT
C9 1/4-S
C8-SGT
C8-S
C8-NGT
C8-N
C6-RGT
C6-R
C6-N
C5-SGT
C5-S
C4-R

To design the perfect telescope family for the beginner or advanced user, you have to think BIG.

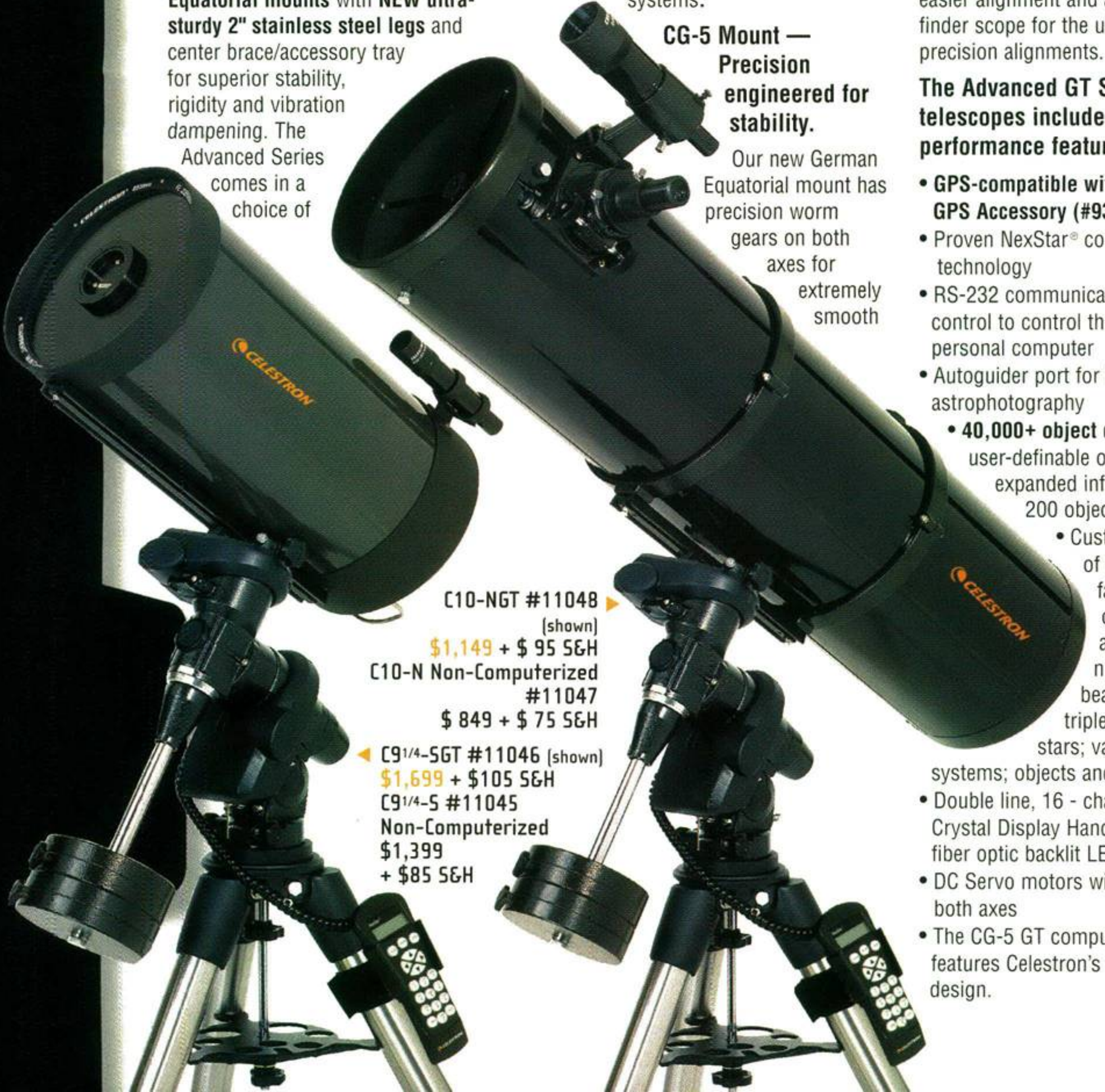
The new Advanced Series family of **computerized GoTo** and non-computerized telescopes was designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace/accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt-Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector. There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's precision **matched** and **hand-figured** optical systems.

CG-5 Mount — Precision engineered for stability.

Our new German Equatorial mount has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger** and **more substantial** legs that offer excellent damping characteristics for more stable views. The CG-5 also has a convenient latitude scale for easier alignment and an optional polar finder scope for the ultimate in precision alignments.

The Advanced GT Series telescopes include these high performance features:

- **GPS-compatible with optional CN16 GPS Accessory (#93963)**
- Proven NexStar® computer control technology
- RS-232 communication port on hand control to control the telescope via a personal computer
- Autoguider port for long exposure astrophotography
- **40,000+ object database** with 400 user-definable objects and expanded information on over 200 objects
- Custom database lists of all the most famous deep-sky objects by name and catalog number; the most beautiful double, triple and quadruple stars; variable star; solar systems; objects and asterisms
- Double line, 16 - character Liquid Crystal Display Hand Control with 19 fiber optic backlit LED buttons
- DC Servo motors with encoders on both axes
- The CG-5 GT computerized mount features Celestron's sleek integrated design.



C10-NGT #11048 ▶ (shown)
$1,149 + $ 95 S&H
C10-N Non-Computerized #11047
$ 849 + $ 75 S&H

◀ C9 1/4-SGT #11046 (shown)
$1,699 + $105 S&H
C9 1/4-S #11045 Non-Computerized
$1,399
+ $85 S&H

GoTo convenience and GPS compatibility for precision accuracy.

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included computerized control system to utilize many of the same functions and features, like the **NexStar computer control system** and an **Autoguider port** for long exposure deep sky astrophotography, as Celestron's most advanced GoTo telescopes. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963)** allowing your telescope to pinpoint your position on the earth, the date and time, and making the alignment process faster and easier than ever before! These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

Specifications — All Advanced Series Telescopes

	21016 C4-R	11071/11072 C5-S	31056 C6-N	21019/21020 C6-R	11025/11024 C8-S	31061/31062 C8-N	11045/11046 C9 1/4-S	11047/11048 C10-N
Optical Design	102mm (4.0") refractor	127mm(5") Schmidt-Cassegrain	150mm (6.0") reflector	150mm (6.0") refractor	203mm (8") Schmidt-Cassegrain	200mm (8.0") reflector	235mm (9.25") Schmidt-Cassegrain	254mm (10") reflector
Focal Length	1000mm f/10	1250mm f/10	750mm f/5	1200mm f/8	2032mm f/10	1000mm f/5	2350mm f/10	1200mm f/4.7
Finderscope	6x30	6x30	6x30	9x50	6x30	9x50	6x30	9x50
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" – 20mm (50x)	1-1/4" – 25mm (50x)	1-1/4" – 20mm (38x)	1-1/4" – 20mm (60x)	1-1/4" – 25mm (81x)	1-1/4" – 20mm (50x)	1-1/4" – 25mm (94x)	1-1/4" – 20mm (60x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CD ROM	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky L1

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons
Motor: Type	DC Servo motors with encoders, both axes
Max Slew Speed	4°/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguide Ports
Tracking Rates	Sidereal, Solar and Lunar
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

C4-R #21016
$ 399 + $40 S&H

C5-SGT
(11072)

C5-SGT #11072 (shown)
$1,099 + $ 75 S&H
C5-S #11071
$ 849 + $65 S&H

C6-N #31056
$ 399 + $50 S&H

C8-SGT
(11026)

C8-SGT #11026 (shown)
$1,299 + $ 75 S&H
C8-S #11025
$ 999 + $85 S&H

C8-NGT
(31062)

C8-NGT #31062 (shown)
$949 + $ 85 S&H
C8-N (31061)
$ 649 + $65 S&H

C6-RGT
(21020)

C6-RGT #21020 (shown)
$ 999 + $ 95 S&H
C6-R #21019
$ 799 + $75 S&H

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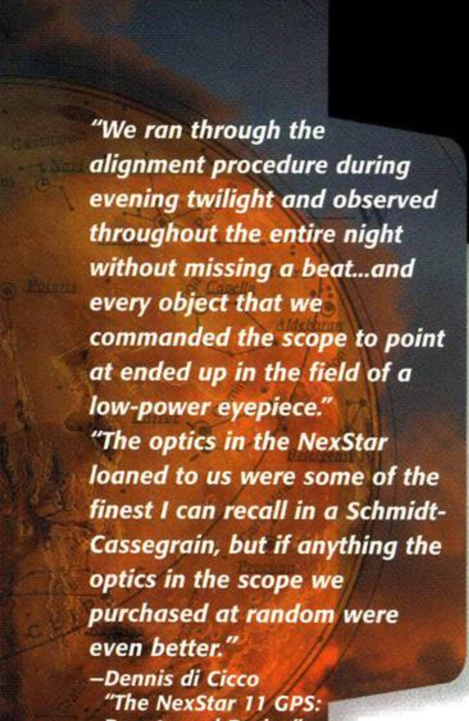

"We ran through the alignment procedure during evening twilight and observed throughout the entire night without missing a beat...and every object that we commanded the scope to point at ended up in the field of a low-power eyepiece."
"The optics in the NexStar loaned to us were some of the finest I can recall in a Schmidt-Cassegrain, but if anything the optics in the scope we purchased at random were even better."

–Dennis di Cicco
"The NexStar 11 GPS: Beauty and Brains"
Sky and Telescope
February 2002

A telescope that combines the design features, engineering, performance, and value of the NexStar® 11GPS doesn't come out of the *Blue*.

CELESTRON
CELESTRON

NexStar® 11GPS
$2999*
+ $125 Shipping & Handling
Includes Standard Heavy-Duty Adjustable Tripod

At Celestron, we know that the whole is greater than the sum of all of its parts. That's why we design, engineer, and manufacture the NexStar 11GPS telescope from the beginning with features and performance that add up to a whole lot more telescope than the competitor's 8", 10" and 12" GPS telescopes — ***and a better value.***

Here's why: Compare the design features and construction of the NexStar 11GPS (as well as the NexStar 8GPS) to the competitor's 12", 10", and 8" GPS telescopes. Every component of the NexStar 11GPS, from its rugged integrated drive base and fork arm design to the unique carbon fiber optical tube assembly has been designed specifically for this model NexStar telescope. Only Celestron matches and meticulously hand-figures each individual telescope optical system.

Understanding Resolution.

Do coatings affect resolution? No! When comparing telescopes, it's extremely important to clearly understand the relationship between coatings and resolution. ***Fact: Resolution is a function of aperture. Coatings only affect light transmission.*** It is a function of aperture or diameter of the objective lens. Rayleigh's Criterion defines resolution as: $\theta = 1.22 * \lambda / D$, where λ is the wavelength of light, D is the diameter of the objective lens, and θ is the resolution in radians. Image brightness is a function of aperture, focal ratio, and system's light transmission efficiency. ***StarBright® coatings have been standard on all of our Schmidt-Cassegrain telescopes since 1983 AT NO ADDITIONAL COST.*** For primary and secondary mirrors, StarBright coating is a precise multilayer application of Al, SiO_2, TiO_2, and then another layer of SiO_2 — all to maximize reflectivity. On the corrector lens we apply precise layers of MgF_2 to both surfaces to maximize transmission.

The dark-adapted (scotopic) eye's peak sensitivity is at 510nm. The sensitivity drops off dramatically on either side of 510nm. In fact, as the wavelength approaches 400nm, the eye's sensitivity goes to almost 0%. The same is true as the wavelength goes to 600nm. Celestron's StarBright® Coatings are designed to peak at 510nm, the peak sensitivity of the scotopic eye. Celestron offers these coatings at no additional cost to the consumer. The chart below shows the transmission at 510nm for both Celestron and competitor's large aperture SCT telescopes.

Transmission at 510nm for all Celestron large aperture SCT's and competitor's SCT's

NexStar 8"	87%	No Additional Cost
NexStar 9.25", 11", 14"	85%	No Additional Cost
Competitor's Standard Coatings - all SCT's	77%	No Additional Cost
Competitor's UHTC	86%	**Cost: $175 (8"), $235 (10"), $295 (12")**

Competitive information obtained from December, 2002 issue of *Sky and Telescope*.

NexStar 11GPS. Quality from the inside out.

Carbon Fiber Tube — Strong and lightweight with 1/4 of the thermal expansion of an aluminum tube. Scratch and dent resistant.

Optical Tube Assembly Outer Rails — An outer rail on each side of the optical tube provides rigid, flex-free movement. Mounting tolerance allows cell to contract and expand.

NexStar quality and reliability. Designed in. Not added on.

COMPARISON OF DESIGN FEATURES

This chart compares the significant design and engineering features of the NexStar 11GPS with competitor's 10" and 12" GPS telescopes.*

Feature/Specification	NexStar 11GPS	Competitor's 10"	Competitor's 12"
Mirror Coatings	StarBright*; 5-step multilayer	Standard; (Enhanced Coatings $235)	Standard; (Enhanced Coatings $295)
Fork Arm	Dual fork tine cast aluminum with integrated hand control receptacle. Fork arms are long enough to permit optical tube to swing through	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket.	Dual fork tine cast aluminum; hand control attaches to fork arm with external bracket; fork arms not long enough to allow optical tube to swing through
Leveling Technique	Internal switch - levels the tube to the mount to the accuracy of 1 arcminute; Usable for both Alt/Az and equatorial	Ground level switch; only useful for Alt/Az	Ground level switch; only useful for Alt/Az
Cord Management	Internal slip ring design. Power is mounted to non-rotating part of drive base. Accessory ports rotate with top of drive base	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling	Requires internal hard stops to avoid tangling and disconnecting wires; accessory ports do not rotate with telescope which can cause cords tangling
Carrying Handles	Ergonomically designed for ease of lifting	Attached to front of fork arms	Attached to front and back of fork arms
Motors	Pittman mfg. in U.S.A.;12V DC Servo; quiet	Unknown; very noisy	Unknown; very noisy
Gears	Berg mfg. in U.S.A.; 5.625" precision bronze gears on both axes; 180-tooth; mated with stainless steel worm shaft	5.75" aluminum gears on both axes	5.75" aluminum gears on both axes
Bearings	9.5" roller azimuth bearing	4" dia. polar bearings	4" dia. polar bearings
Focusing Mechanism	Two (2) preloaded ball bearings	Bushing and washer	Bushing and washer
Optical Tube	Carbon Fiber; reduces thermal expansion; 4x less than aluminum	Aluminum	Aluminum
Fastar Compatible	Yes	No	No
Weight of Telescope	63 lbs.	62 lbs	75 lbs
GoTo Precision	1.5 arcminutes	2 arcminutes	2 arcminutes
Boot-up Time	1-1.5 sec.	20-25 sec.	20-25 sec.
GPS Alignment Time	2.5 min.	More than 4.5 min.	More than 4.5 min.
Quick Align	Yes	No	No
Database Filter Limits	Automatic filter limits for named objects list	No database filter limits for custom object lists	No database filter limits for custom object lists
Price**	**$2,999 + $125 S&H = $3,124**	**$2,495 + $145 S&H + $235 for Enhanced coatings = $2,875**	**$2,995 + $215 S&H + $295 for Enhanced coatings = $3,505**

How you can tell wrong from right.

Celestron strongly believes that the only way to design and manufacture our NexStar GPS telescopes is the ***right way***. The right way means understanding what expectations our customers have when they make an investment in our products, and designing and manufacturing telescopes that meet or exceed their expectations. That means paying attention to details and not cutting corners. Compare the following examples of why we believe that we have designed the NexStar 8GPS and 11GPS the right way and what we believe is wrong with the design of the competitor's GPS telescopes. Consult the chart to the left for an additional comparison.

Their Way:

- The competitor's GPS antenna is partially obstructed by the finderscope.
- When the base rotates, cables can easily wrap around the fork arms and become entangled.
- Carrying handles are poorly designed and located making it difficult to lift the telescope.
- Boot-up time can take as much as 20-25 sec.
- Hand control displays objects below the horizon.
- Motors and gearbox are noisy.
- The competitor's 10", and 12" drive base is undersized.
- The OTA (Optical Tube Assembly) on the competitor's 12" will not swing through and clear the drive base; the fork arms have spacers to attach to the base.
- The complete optical system is not hand-figured.
- The hand control is attached to a bracket with the cable hanging loose.
- Enhanced optical coatings cost extra
- Focus mechanism uses bushings intead of ball bearings.

Our Way:

- Celestron's GPS antenna is not obstructed by the finderscope.
- Celestron's drive base design eliminates any potential for cord/cable wrap.
- Carrying handles are integrated into fork arms to make lifting and transporting easier.
- Boot-up and alignment are fast and easy.
- Hand control has many advanced features and is user-friendly; only shows objects above the horizon.
- High quality precision gearing ensures quiet, precise operation.
- Large diameter drive base and bearing track provides maximum stability. Especially important when equatorially mounted.
- Carbon fiber tube minimizes thermal expansion/contraction; important for astrophotography or CCD imaging.
- Mirror shift minimized through use of precision bearings.

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* Version Tested: 1.0b Telescope Serial #01039 All comparative information obtained from User Manual for this model.

**Prices obtained from December, 2002 issue of *Sky & Telescope*
Set-up Information: Starting Position: Alt.= -90 and Az =0
Date: 09.18.02 Time: 8:00 PM (no daylight savings) Long: 118 West Lat: 34 North

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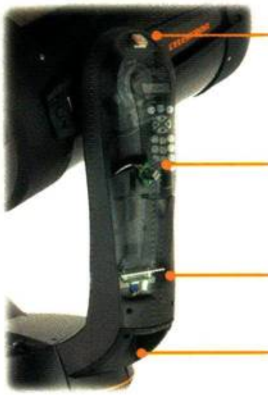
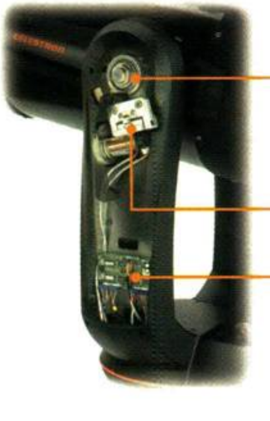


16-channel GPS — ***Interference free. Finderscope is positioned away from GPS antenna. Pinpoints your exact location on Earth with an unobstructed view.***

Upgraded hand control and software features — ***40,000 object database; new features include compass calibration, polar alignment routine, EQ AutoAlign, database filter limits, hibernate, Auto north and level, wedge align algorithm, Quick Align, user-defined slew limits.***

Electronic compass — ***Finds true North when used in conjunction with NexStar software.***

Ergonomically designed fork arm with integral handles — ***Integrated handles in fork arms designed for ease of carrying and safe and easy setup and transportation.***



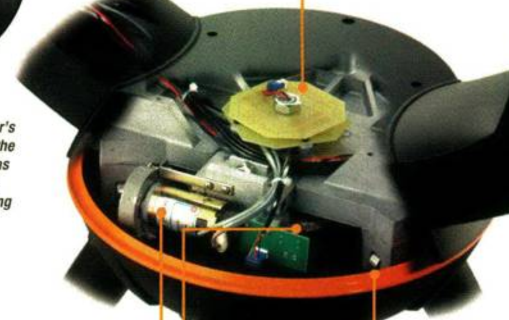
Bearing and shaft — ***Heavy-duty preloaded tapered roller bearing on both axes.***

Worm shaft — ***Stainless steel worm shaft has .4375 pitch diameter and is preloaded with two ball bearings. The worm is made from a single piece of steel to minimize run-out, which is the source of periodic error.***

Heavy-duty aluminum spring loaded worm block — ***On both axes; minimizes backlash.***

Motor board — ***Each axis is controlled by its own 8-bit microcontroller.***

Auxiliary Ports — ***The NexStar's auxiliary ports are located on the top of the base which rotates as the telescope turns preventing accessory cables from wrapping around fork arms.***



Internal Slip Ring — ***The NexStar's power cables will never wrap and telescope accessory cables will not get wrapped around the telescope.***

Drive Motors — ***Made in the U.S.A., Pittman Lo-Cog™ brush commutated DC motors offer smooth, quiet operation and long life. The motor armatures are skewed to minimize cogging which is required for low speed tracking. Windings are resin impregnated for greater reliability in incremental motion application.***

Precision bronze gear — ***32 pitch, 5.625" pitch diameter, 180-tooth bronze gear. Manufactured in the U.S.A. by W.M. Berg, Inc. Manufactured to AGMA Quality Class 10 standard which minimizes total composite error and backlash.***

Unique roller bearing design — ***Base rotates around a wide 9.5" track for maximum stability; especially important when equatorially mounting for imaging.***

To take a virtual tour of the NexStar 11GPS or to locate your nearest Authorized Celestron Dealer, please visit us at www.celestron.com

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Lonely planet

UNIDENTIFIED FLOATING OBJECTS the size of planets are turning up in the unlikeliest of places — far away from stars. Scientists aren't sure how they got there or even what to call them. *ASTRONOMY:* ROEN KELLY

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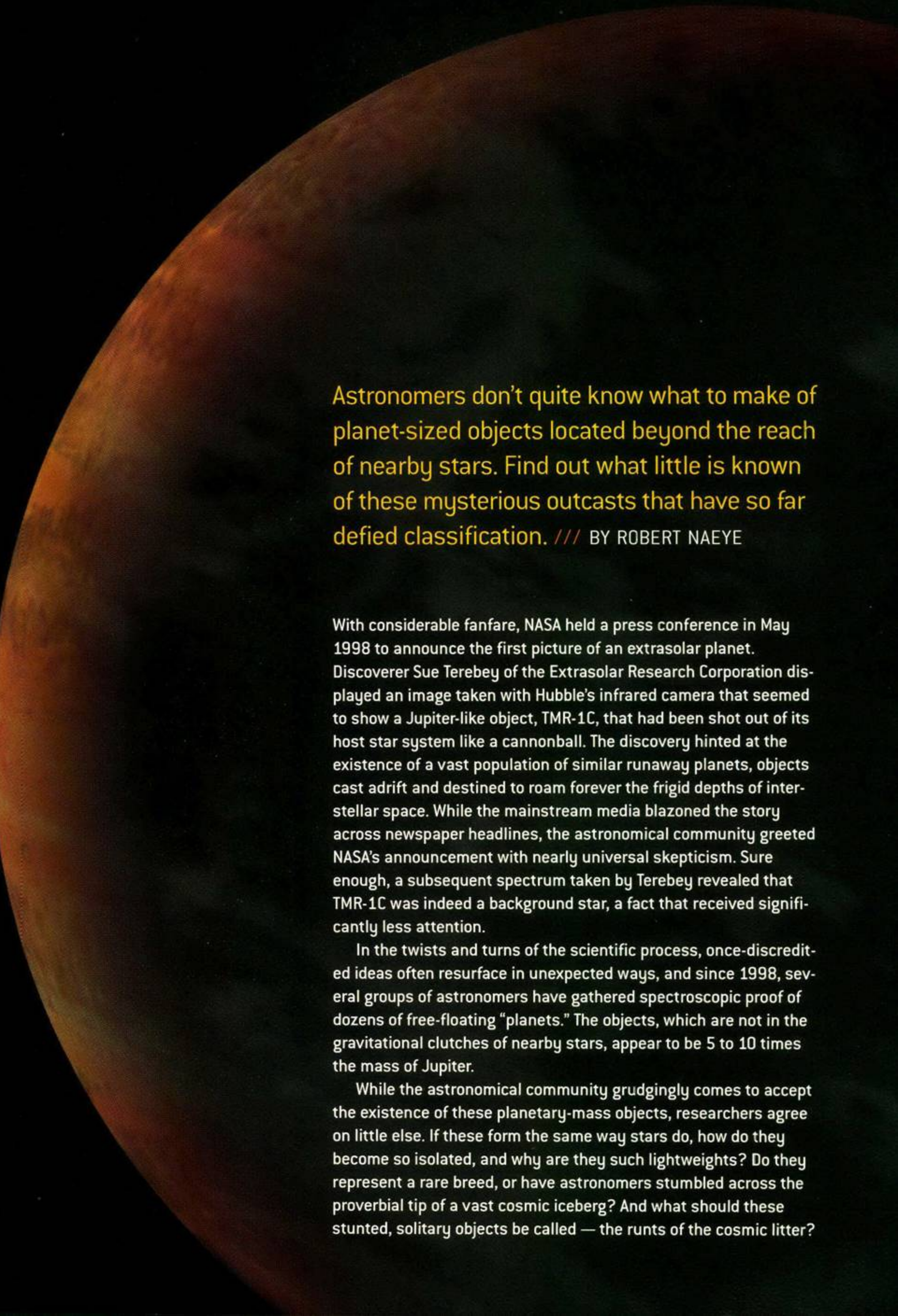


Astronomers don't quite know what to make of planet-sized objects located beyond the reach of nearby stars. Find out what little is known of these mysterious outcasts that have so far defied classification. /// BY ROBERT NAEYE

With considerable fanfare, NASA held a press conference in May 1998 to announce the first picture of an extrasolar planet. Discoverer Sue Terebey of the Extrasolar Research Corporation displayed an image taken with Hubble's infrared camera that seemed to show a Jupiter-like object, TMR-1C, that had been shot out of its host star system like a cannonball. The discovery hinted at the existence of a vast population of similar runaway planets, objects cast adrift and destined to roam forever the frigid depths of interstellar space. While the mainstream media blazoned the story across newspaper headlines, the astronomical community greeted NASA's announcement with nearly universal skepticism. Sure enough, a subsequent spectrum taken by Terebey revealed that TMR-1C was indeed a background star, a fact that received significantly less attention.

In the twists and turns of the scientific process, once-discredited ideas often resurface in unexpected ways, and since 1998, several groups of astronomers have gathered spectroscopic proof of dozens of free-floating "planets." The objects, which are not in the gravitational clutches of nearby stars, appear to be 5 to 10 times the mass of Jupiter.

While the astronomical community grudgingly comes to accept the existence of these planetary-mass objects, researchers agree on little else. If these form the same way stars do, how do they become so isolated, and why are they such lightweights? Do they represent a rare breed, or have astronomers stumbled across the proverbial tip of a vast cosmic iceberg? And what should these stunted, solitary objects be called — the runts of the cosmic litter?

An unassuming entrance

The first mention of these mysterious outliers came in the November 6, 1998, issue of the prestigious journal *Science*, when a Japanese team led by Motohide Tamura of the National Astronomical Observatory of Japan reported the discovery of two isolated planetary-mass objects (PMOs for short). Perhaps aware of the TMR-1C controversy, Tamura's team titled the paper "Isolated and Companion Young Brown Dwarfs in the Taurus and Chamaeleon Molecular Clouds," neglecting to mention the potentially ground-breaking discovery there or in the abstract. It buried the announcement in a single, conservatively worded paragraph near the end of the paper. Not surprisingly, few professional astronomers took note, and the media never picked up the story.

> Calling them "planets" implies swarms of Jupiters stripped from their parent stars, a scenario currently unsupported by any evidence. – MARK McCAUGHREAN

The team's caution is understandable, given the tenuous nature of its evidence. Using an infrared CCD coupled to the 1.5-meter telescope at the Cerro Tololo Inter-American Observatory in Chile, the astronomers found six objects in a star-forming cloud in the constellation Chamaeleon.

When they tried to categorize their find, they immediately ruled out one possibility — if the objects lay at the distance of the cloud, their light was too feeble and reddish to come from stars. Membership in this class of objects is pretty cut and dried — the title of "star" goes to a luminous body with more than about 75 Jupiter masses, or 1/14 the mass of the Sun. At that threshold, the objects have enough mass to squeeze their cores to temperatures and pressures high enough to begin — and, crucially, sustain — hydrogen fusion. Objects below this mass are called brown dwarfs.

Here's where things get dicey. The two dimmest objects found by Tamura's team don't even qualify as brown dwarfs, the middleweight class of "failed stars" that scientists tend to define by process of elimination — they're smaller than stars but bigger than planets. But what distinguishes brown dwarfs and planets? According to many, that boundary should be set at 13 Jupiter-masses. Objects above that divide can generate energy for a few million years by fusing deuterium (hydrogen that has a neutron in addition to the single proton) into heavier elements. Anything less massive cannot ignite fusion at all.

Tamura and his colleagues had cause for both excitement and concern. The two Chamaeleon objects that were so faint they appeared to fall below the 13-Jupiter-mass brown dwarf cutoff were also isolated — how could the scientists determine the mass of something that is not being gravitationally influenced by a nearby object? Tamura's team resorted to indirect methods, comparing the faint objects' infrared luminosities and estimated ages with theoretical models.

Robert Naeye *is editor of* Mercury, *the bimonthly magazine of the Astronomical Society of the Pacific. His last article for* Astronomy *was "Unlocking New Worlds," in the November 2002 issue.*

These models are based on thermodynamical calculations of how young, low-mass bodies cool. When objects form, either from collapsing pockets of gas in a cloud, or by the slow buildup of accreting planetesimals in a disk, they start out hot from the gravitational energy of infalling matter and contraction. Substellar objects such as brown dwarfs and planets retain heat left over from their formation, which they gradually radiate into space. Jupiter, for example, still radiates more energy (mostly in the infrared and radio) than it receives from the Sun. Because more massive objects have a smaller ratio of surface area to volume, they cool more slowly than do less massive objects.

The young stars in the Chamaeleon cloud are estimated to be between one million and 10 million years old, so according to models, the two faint objects discovered by Tamura's team tip the scales at less than 12 Jupiter masses. "The mass estimates depend on the evolutionary models, and this is a problem we have to face in deriving mass," says team member Yumiko Oasa of the University of Tokyo. "But the estimated age is not considered to be preposterous."

What's in a name?

In March 1999, the controversy over isolated PMOs burst into the limelight at a conference in Antofagasta, Chile. There, a group of Spanish astronomers led by Maria Rosa Zapatero Osorio, then at the Astrophysics Institute of the Canary Islands, announced the discovery of a planetary-mass object in the Sigma Orionis star-forming region, near Orion's Belt. In a 2000 *Science* article, the Spanish group reported no less than 18 unattached PMOs in Sigma Orionis.

Unlike the Japanese team, this group published spectra of three PMOs, which showed unequivocally that these objects were extremely cool (2,600° to 3,500° F; for reference, the Sun is 9,980° F) for their ages. If the cluster is one million to five million years old, as nearly everyone agrees, the evolutionary models clearly pegged these objects at 5 to 15 Jupiters in mass. "It was only after the Spanish group got spectra that people took these objects seriously," says University of Michigan astronomer Ray Jayawardhana.

But the Spanish team did manage to draw the ire of professional colleagues. In both their *Science* paper and in subsequent media interviews, team members used the loaded "p" word to describe these objects. Many astronomers were quick to acknowledge the significance of the discovery, but few agreed with calling these objects "planets." In an article in the February 23, 2001, issue of *Science*, Mark McCaughrean of Germany's Astrophysikalisches Institut Potsdam wrote, "Calling them 'planets' implies swarms of Jupiters stripped from their parent stars, a scenario currently unsupported by any evidence, and one that has created confusion in the press."

More evidence for isolated PMOs surfaced in 2000, when British astronomers Philip Lucas of the University of

MEDIA HOOPLA OVER TMR-1C turned out to be much ado about nothing when astronomers discovered that the object [lower-left corner] was not an extrasolar planet ejected from the binary star pair TMR-1 but a background star. S. TEREBEY [EXTRASOLAR RESEARCH CORP.] AND NASA

STARS IN THE TRAPEZIUM, the central cluster in the Orion Nebula, outshine the planetary-mass objects that lie hidden in this infrared image by the Hubble Space Telescope. Thirteen PMOs were found here in 2000. NASA, K. L. LUHMAN [CFA], G. SCHNEIDER, E. YOUNG, G. RIEKE, A. COTERA, H. CHEN, M. RIEKE, R. THOMPSON [U. ARIZONA]

Hertfordshire and Patrick Roche of Oxford University announced the discovery of 13 isolated PMOs in the Trapezium Cluster, at the heart of the Orion Nebula. If these objects are located in the Trapezium, if they have the same age as the other Trapezium stars (about one million years), and if the evolutionary models are correct, these objects have masses between 5 and 15 Jupiters. That's a lot of "ifs." Like the Japanese team, Lucas and Roche published no other supporting evidence.

Lucas and Roche's claim was greeted with outright skepticism. Some astronomers argued the Trapezium was older than one million years, meaning these objects had more time to cool and were, therefore, more massive according to theoretical models. This would push their masses well into the brown dwarf regime. Other astronomers argued that the objects were not inside but *behind* the Orion Nebula, whose gas and dust reddened the objects, making them appear much less luminous than they really are.

A year later, Lucas and Roche published infrared spectra of 20 objects in the Trapezium Cluster, corroborating their earlier report — water vapor in the objects' atmospheres confirmed the fainter ones were so cool for their ages they are almost certainly PMOs. Lucas and Roche called their finds "planetars," a contraction of the mouthful "planetary-mass object believed to have formed like a star." While the name *planetar* has not exactly caught on, the tide was turning in favor of the existence of isolated PMOs.

The case was strengthened further this year, when Subhanjoy Mohanty of the Harvard-Smithsonian Center for Astrophysics, Ray Jayawardhana, and Gibor Basri of the University of California–Berkeley, reported the discovery of two PMOs with masses of about six Jupiters in the Upper Scorpius star-forming region.

Unlike previous teams, Mohanty, Jayawardhana, and Basri surveyed the surface gravity of their candidate PMOs — an ideal measurement as gravity is directly correlated to mass. They did this by taking high-resolution optical spectra of the objects with the 10-meter Keck I Telescope. These observations revealed not only a low temperature of 4,220° F, but also minimal broadening of sodium and potassium spectral lines, which indicates a low-gravity atmosphere (because the density of atoms and molecules is low). "I'm thinking of every possible way I can to destroy this result, and I haven't been able to. It's very hard to push the mass up to a brown dwarf," says Basri.

"We can be confident that these two Upper Scorpius objects are very low mass. We're not just measuring the brightness and putting it down on a cooling curve," adds Jayawardhana. He lays down the gauntlet by adding, "Since we're finding PMOs in yet another region, it's hard to escape the conclusion that these objects are pretty common. It's a challenge to the theorists to explain the formation of these objects."

Cast-away planets?

According to the standard theories of star formation used just a few years ago, solitary objects with the masses of a few Jupiters should not exist. These theories invoked what is known as the "Jeans mass," after early-20th-century British physicist Sir James Jeans. The Jeans mass is the lowest possible mass that a clump of gas can have in a given gas cloud in order to collapse gravitationally and form a star. Based on this reasoning, objects less massive than perhaps a dozen Jupiters were not expected to form by the standard mechanism of star formation.

Initial speculation focused on the possibility that isolated PMOs form inside circumstellar disks, like planets, and are later gravitationally slingshot out of the system through interactions with more massive planets. But the preponderance of evidence argues strongly against that scenario. The current radial velocity surveys for extrasolar planets, like the one conducted by the group led by Geoff Marcy of the University of California–Berkeley, are finding very few planets massive enough to eject isolated PMOs. Second, while the abundance of isolated PMOs remains a profound mystery, the disk ejection scenario can't explain the numbers that are being found.

In 2001, Bo Reipurth of the University of Colorado and Cathie Clarke of Cambridge University in England proposed that some or all isolated PMOs are ejected much earlier in the star formation process. In the Reipurth/Clarke model, a collapsing gas cloud will form numerous dense cores — the gaseous embryos of new stars. The most massive cores sink to the center of the clouds. Gravitational interactions between the cores hurl the less massive ones out of the mother cloud. Like chicks thrown out of a nest, these embryos are deprived of material to feed on, so they never have the opportunity to grow into full-fledged stars. In this model, many or most of the galaxy's brown dwarfs and isolated PMOs are mere runts, the losers in a race to gobble up gas.

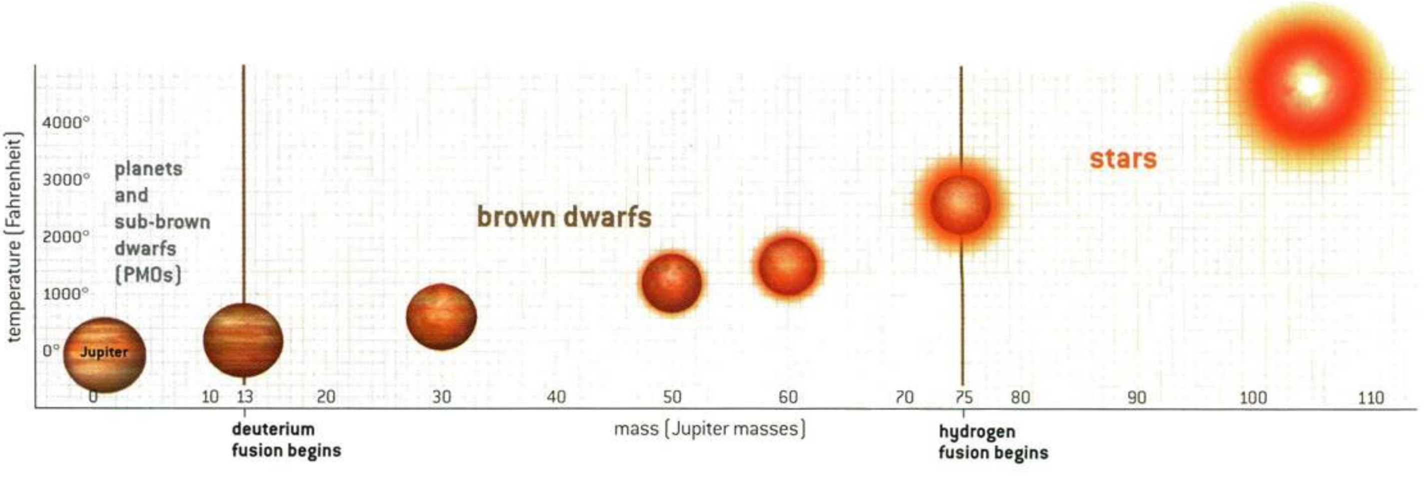
Confirming the Reipurth/Clarke model with observations will be difficult. A gaseous embryo will be ejected at a typical velocity of a mere one kilometer per second, which is easily masked by the random stellar velocities within a cloud. "We don't have compelling observational evidence that they are ejected, but that doesn't mean at least some of them are not," says Jayawardhana.

Considerable theoretical support for the Reipurth/Clarke ejection model emerged last summer in a supercomputer simulation of star formation conducted by Matthew Bate of the University of Exeter, Ian Bonnell of the University of St. Andrews (both in England), and Volker Bromm of the Harvard-Smithsonian Center for Astrophysics. The supercomputer simulation, the most ambitious ever performed of the star-formation process, modeled the collapse and fragmentation of a 1.2-light-year-wide interstellar gas cloud over 266,000 years. The simulation revealed that star formation is a messy, chaotic process in which large numbers of low-mass cores are hurled from the mother cloud before they can grow to stellar masses. "My simulation agrees with the Reipurth and Clarke model," says Bate, who adds that it "produces objects down to around five Jupiter masses, but the exact value of the cutoff cannot be determined from my calculations."

> [The definition of a sub-brown dwarf] doesn't satisfy anyone on the committee but rather irritates all of us more or less equally. – ALAN BOSS

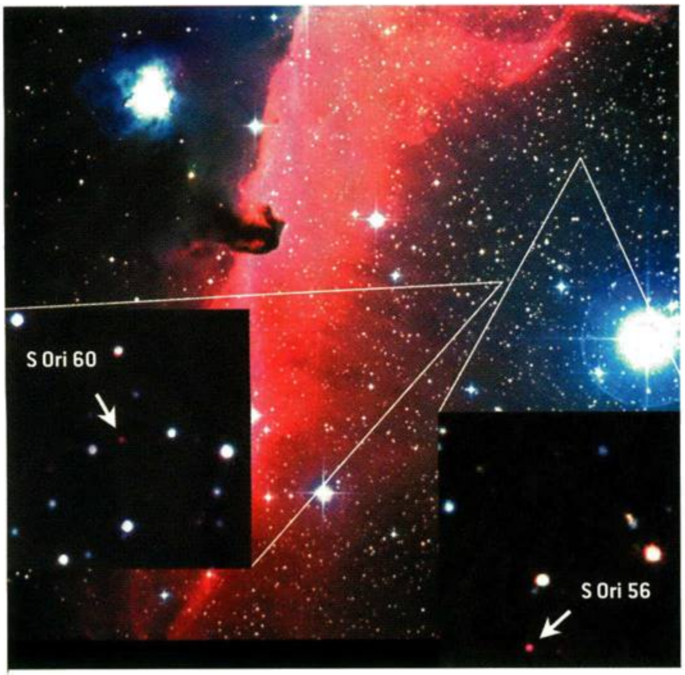
Still, the number of ejections in the simulations don't account for the collections of brown dwarfs and PMOs observed. Some other mechanism must also be at play. Perhaps turbulent motions within clouds could lead to the direct collapse of gas into PMOs, as suggested in some computer models. Magnetic fields might even slice through clouds like cookie cutters, according to Alan Boss, a theorist at the Carnegie Institution of Washington. He has performed simulations suggesting that these fields could force collapsing clumps of gas in interstellar clouds to fragment into even smaller clumps, some of which would be ejected and could go on to form objects as low in mass as Saturn.

"If Alan Boss's models are able to form all these objects, then by Occam's razor, there's no reason to invoke all sorts of exotic phenomena to explain them. But that's a large *if*," says Mohanty. "All of them are viable options. I don't think there's any way right now to differentiate between them." Even Boss concedes, "We're still early in the process of thinking this through."

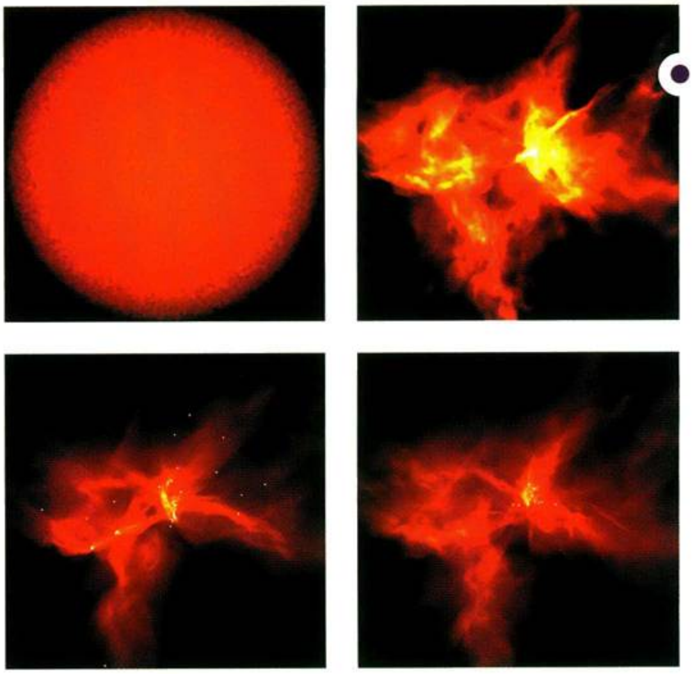


WHAT BECOMES A PLANET MOST? The answer is anything but clear as astronomers weigh the importance of properties such as mass, formation, and presence of a host star. The International Astronomical Union has tentatively set out the categories above, which are sure to change as research progresses.

ASTRONOMY: ROEN KELLY



THE CASE FOR PMOs was strengthened when a group of Spanish astronomers published the spectra of three objects (Sigma Orionis 60 and 56 are shown above) in the Sigma Orionis star-forming region. Their light signatures showed the objects were indeed cool enough to be the size of planets, which is how the researchers referred to them. Other astronomers contested this, arguing the term *planet* suggested the objects had once orbited a star, which is still unknown. GABRIEL PÉREZ/IAC



COMPUTER SIMULATIONS such as this one (which proceeds clockwise from top left) suggest isolated planetary-mass objects form as stars that suffer arrested development. Fifty times as massive as the Sun and 1.2 light-years across, an interstellar gas cloud collapses due to gravity into a dense core. Violent interactions between the stars and brown dwarfs born there fling some PMOs into exile in space, explaining why they lack nearby host stars. The simulation covers 266,000 years. MATTHEW BATE, UNIVERSITY OF EXETER

A planet by any other name

Just as the debate rages about whether Pluto is a bona fide planet, astronomers still can't agree on what to call these isolated PMOs. As Ray Jayawardhana points out, the lowest-mass PMOs appear to be even lower in mass than some of the extrasolar planets that have been found orbiting stars. "This blurs the lines between planets and brown dwarfs, and there could be an overlap in mass," he says.

The usual decorum of scientific discourse occasionally gets thrown out the window as astronomers debate the virtues of names such as planemos, planetars, sub-brown dwarfs, and *xebarci* (Greek for "wandering sailors"). A schoolchild in Nevada even suggested the name *ornet*, for "orphan planet." It seems the list of monikers could fill a volume as thick as Tolstoy's *War and Peace*.

The organization that resolves such matters, the International Astronomical Union (IAU), has no universally accepted definition of exactly what constitutes a "brown dwarf" or a "planet." For the time being, the IAU's committee on extrasolar planets, which is chaired by Alan Boss, is sticking by the policy that regardless of whether it orbits a star, any object between 13 and 75 Jupiter-masses is a "brown dwarf" and isolated objects below 13 Jupiters are "sub-brown dwarfs." "This definition is a compromise that doesn't satisfy anyone on the committee, but rather irritates all of us more or less equally," jokes Boss. "It is the best that the committee can agree upon. We expect this definition to evolve as our knowledge improves."

But Eduardo Martín of the University of Hawaii, a member of the Spanish team that found PMOs in Sigma Orionis, counters, "I think we should call them 'planets' because their structure is not affected by whether they orbit a star or not." Isolated PMOs have temperatures around 3,140° F when they form, but over hundreds of millions of years they cool below –280° F. In their old age, they look very much like Jupiter. In this sense, isolated PMOs give us a golden opportunity to see what Jupiter and Saturn were like in their youths.

Gibor Basri, who has written extensively on the classification issue, says the main sticking points are how much weight to assign to the objects' formation, circumstances (do they orbit stars?), and physical properties (especially mass). According to Basri, "A 'planet' is a spherical non-fusor born in orbit around an object that experiences fusion sometime during its lifetime." In this case, isolated PMOs are not planets per se, because they presumably did not form in orbit around stars or brown dwarfs.

"At this point, I'm more concerned about what they are and how they form than what we call them," says Jayawardhana. "The name that gets used the most is probably the one that will stick, and that will depend on who writes the most papers." At the moment, the term *planetary-mass object* appears to be winning.

Clearly, our current terminology is not sophisticated enough to match nature's bewildering and beautiful complexity. The nomenclature debate is a sign of a healthy and vibrant science, one in which our outmoded ways of thinking about the universe are struggling to keep pace with the rapidly advancing rate of astronomical discovery.

To learn more about these free-floating planets and their garden-variety exoplanet cousins, visit http://www.astronomy.com/toc

{ LUNAR EXPLORATION }

Harvest the MOON

The next goal for human space flight should be the same as the first: Earth's Moon. /// PAUL D. SPUDIS

More than half the people now alive were born after America last went to the Moon. Yet if asked, today's students would probably say that existing technology could get us there and land on the surface. In reality, the hardware, software, and know-how needed for lunar flight were dismantled almost 30 years ago. America stopped going to the Moon because the reason to go had been satisfied. We went to beat the Soviets — and we stopped going because once a battle is won, you don't keep fighting it.

Fixing the problems that caused the loss of the Shuttle Columbia has NASA's full attention at present. But the agency must move forward, and soon it, like everyone else involved in space, will be focusing on what the next goal might be. NASA has advanced studies examining possible directions. Build large astronomical instruments in deep space? Visit an asteroid? Send people to Mars?

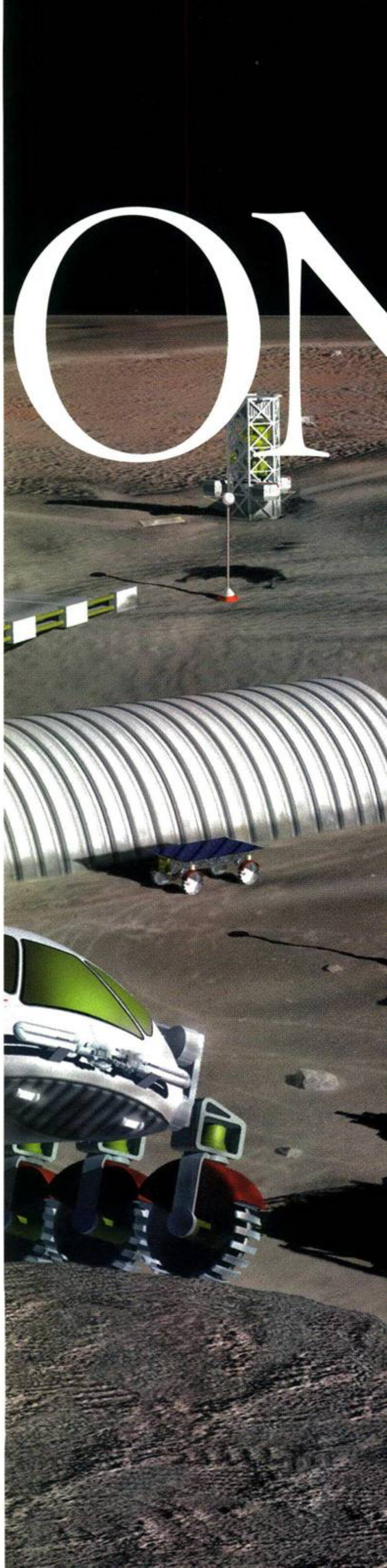
The urge to explore beyond familiar horizons is one of humanity's greatest drives. We need a new challenge in space. It must be difficult yet achievable, substantial yet manageable. It should encourage new technology, yet be attainable on a limited budget. Without such a significant goal, the space program will circle aimlessly in a deteriorating orbit.

One outstanding target awaits in our backyard. The Moon offers scientific and technical benefits, as well as more tangible ones. In the 1960s, we raced to the Moon because it was a fence thought to be just jumpable. When we return, we'll go for different reasons — not to prove that we can do it, but because we understand the Moon's true value.

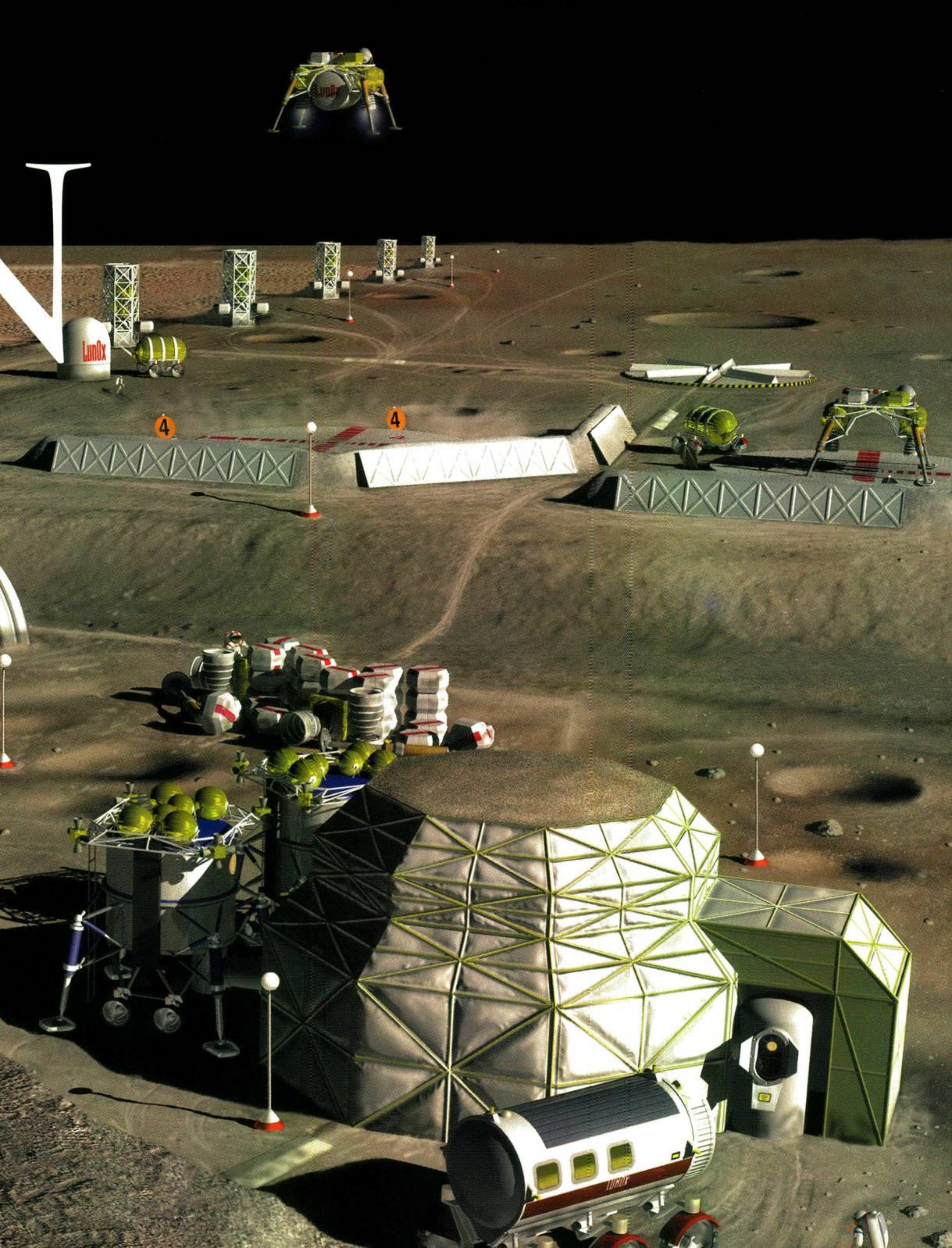
Four reasons to return

The first motivation to revisit the Moon is that its rocks hold the early history of our own planet and the solar system. Next, its unique environment and properties make it an ideal vantage point for observing the universe. The Moon is also a natural space station where we can learn how to live off-planet. And finally, it gives us an extraterrestrial filling station, with resources to use both locally and in near-Earth space.

Often pictured as a simple, primitive body, the Moon is actually a small planet of surprising complexity. The period when it was most active geologically, between 4 billion and 3 billion years ago, corresponds to a missing chapter of



A LUNAR MINING FACILITY harvests oxygen from the soil of Mare Serenitatis. The Moon's abundant resources will help open up the entire solar system for human exploration. NASA; ILLUSTRATION BY PAT RAWLINGS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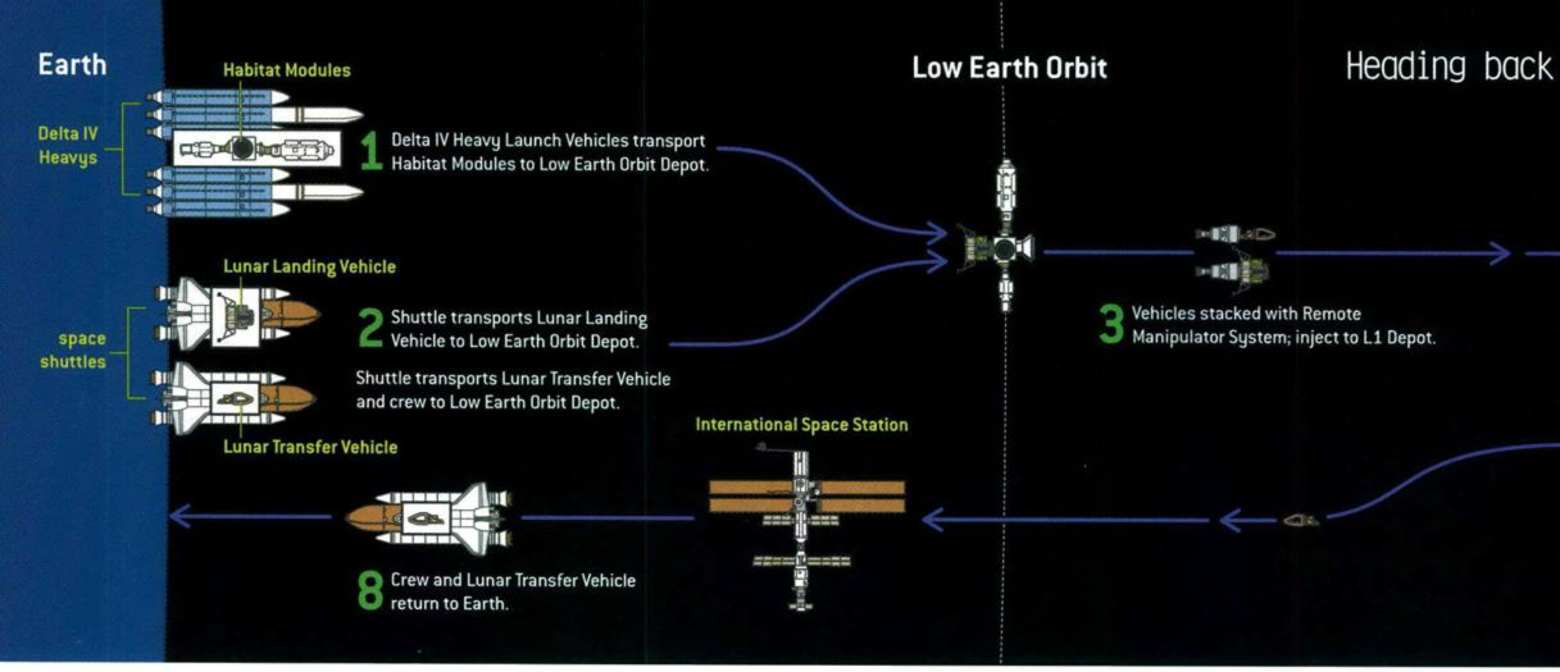

Earth
Habitat Modules
Delta IV Heavys
1 Delta IV Heavy Launch Vehicles transport Habitat Modules to Low Earth Orbit Depot.
Lunar Landing Vehicle
space shuttles
2 Shuttle transports Lunar Landing Vehicle to Low Earth Orbit Depot.
Shuttle transports Lunar Transfer Vehicle and crew to Low Earth Orbit Depot.
Lunar Transfer Vehicle
Low Earth Orbit
Heading back
3 Vehicles stacked with Remote Manipulator System; inject to L1 Depot.
International Space Station
8 Crew and Lunar Transfer Vehicle return to Earth.

Earth's history. The processes that transformed the Moon — impact, volcanism, and tectonism (crustal deformation) — affect all the rocky bodies of the inner solar system. Because the Moon has no atmosphere or flowing water, the geological story of its ancient surface can be read clearly. And as Earth's companion, it retains a record of the history in this corner of the solar system, vital knowledge unavailable on any other object.

> It once took a gigantic Saturn V booster to get us to the Moon's surface. We now have cheaper and far better ways to go.

The biggest scientific benefit of the Apollo program was learning the importance that impact cratering had in the evolution of planets. This new understanding turned out to have profound consequences. Scientists now know that impacts of large bodies periodically wipe out species on Earth, most notably 65 million years ago when the dinosaurs and many others met their demise. The Moon taught us how to spot the telltale residue of large impacts in Earth's past, but our knowledge remains incomplete. While Earth's surface record has been erased by erosion and crustal recycling, we can turn to the ancient lunar surface, which still holds its impact history.

For astronomical observations, the Moon offers a premier place: It has no atmosphere and is a quiet, stable body. The lack of an atmosphere permits clear viewing with no opaque portions of the spectrum to contend with — all of nature's radiation can be viewed from the Moon's surface. Because one lunar day lasts 709 hours, or 29.5 terrestrial days, there are long periods of near-continuous sunlight and darkness. Even during the lunar day, brighter sky objects remain visible in a black sky. The far side of the Moon is permanently shielded from the din of civilization's electromagnetic noise. And near the lunar poles lie areas of perpetual darkness and sunlight. The dark regions remain very cold, only a few tens of degrees above absolute zero, providing natural cold-traps that can cool infrared detectors for free.

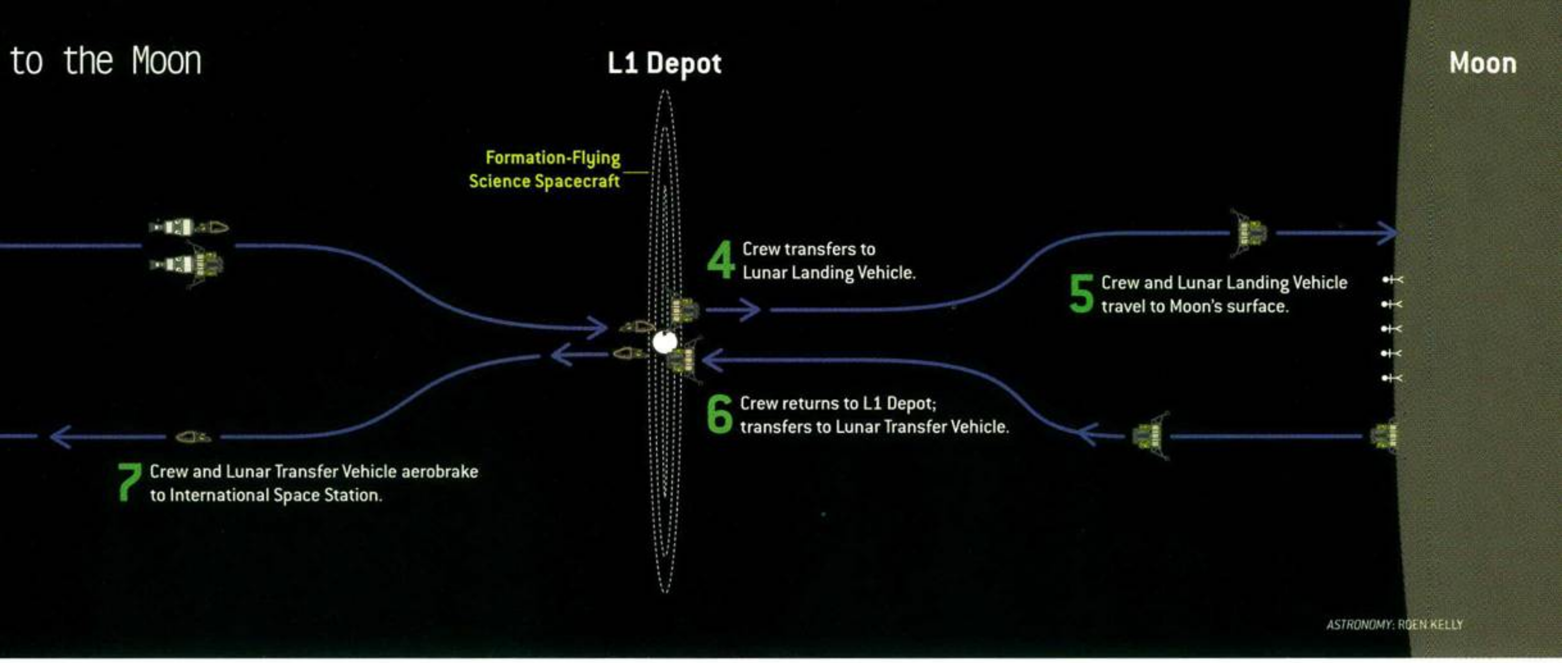
The Moon also beckons as another home for humanity — not for territorial expansion, but as a laboratory where humans can learn to survive and thrive off-Earth. Exploration is a task that we only *think* we understand. The endless debate between advocates of human and robotic space flight highlight this ignorance. Instead of asking, "Which is better: humans or robots?", we should be asking: "How can we use both most effectively?"

Exploring any planet is a job for generations, but efficient ways to do it exist. The Moon is a natural laboratory for discovering the best strategies.

Yet resources may well prove the most important reason to return. Materials and energy available on the Moon will open up the space frontier. Shadowed areas near the lunar poles can do more than cool telescopes: They contain vast deposits of water ice, emplaced by a steady rain of comets over billions of years. Scientists estimate that more than 10 billion metric tons of water exist in these regions. Vital for human life, water can also be broken down into hydrogen and oxygen to make rocket propellant. Water from lunar cold-traps can thus help create our first space filling station.

It's true that hydrogen and oxygen can be extracted directly from lunar soil. The solar wind implants hydrogen on the dust grains, and oxygen is locked in the minerals. This means rocket propellant and water could, in principle, come directly from the bone-dry dust. Yet such processing would be difficult and costly. Polar water is already in a concentrated, useful form, greatly simplifying the scenarios for lunar return and habitation.

Paul D. Spudis *is a planetary scientist and author of* The Once and Future Moon, *published by the Smithsonian Institution Press. His new book is* The Clementine Atlas of the Moon, *to be published by Cambridge University Press.*


to the Moon
L1 Depot
Moon
Formation-Flying Science Spacecraft
4 Crew transfers to Lunar Landing Vehicle.
5 Crew and Lunar Landing Vehicle travel to Moon's surface.
6 Crew returns to L1 Depot; transfers to Lunar Transfer Vehicle.
7 Crew and Lunar Transfer Vehicle aerobrake to International Space Station.

ASTRONOMY: ROEN KELLY

The lunar poles have uses from yet another resource perspective — the areas of permanent darkness lie close to areas of near-permanent sunlight. The Moon has no seasons to speak of because its rotation axis stands nearly perpendicular to the plane of Earth's orbit. This means the Sun always appears on or near the horizon at the poles.

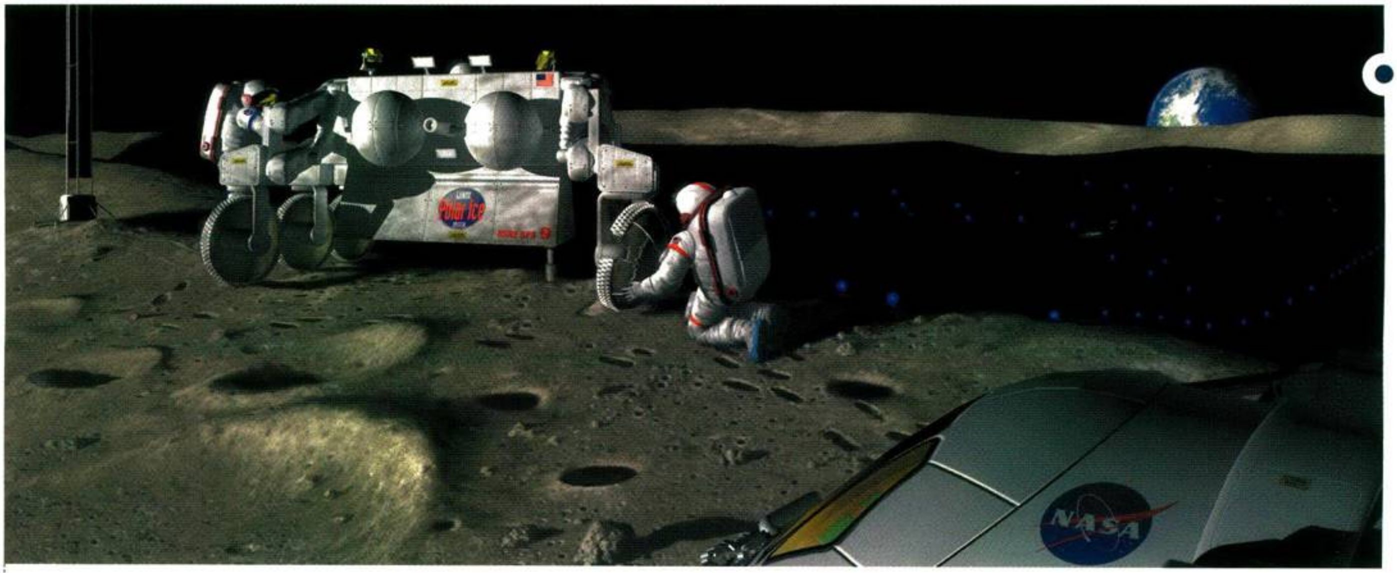
Scientists have identified several polar regions that receive sunlight for more than 75 percent of the lunar day. Thus, an outpost in these areas will have ample sunlight to generate electrical power via solar cells. They also have a benign thermal environment because sunlight strikes the polar ground at a shallow angle. Surface temperatures never reach those found at noon on the lunar equator (about 212° Fahrenheit or 100° Celsius). The lunar poles make inviting oases in near-Earth space.

Using off-planet resources presents us with a challenge and a worthwhile goal. If Earth is our only source of materials, we'll never go very far in space. We have to cut the umbilical cord with Earth. Having a Moon endowed with usable resources opens up the solar system — yet we have to learn how to use these resources before we go farther.

An architecture for return

Forty years ago, America built the mighty Saturn V booster rocket to launch men and machines to the Moon in a single leap. Indeed, this brute-force approach was so successful it has dominated lunar-return plans ever since. Nearly every Moon-mission scheme of the past 20 years starts with rebuilding the heavy-launch capability of the Saturn V or its equivalent. This thinking, however, has technological tunnel vision.

Parts of the Saturn V were literally hand-made, making it hugely expensive, and developing any new launch vehicle is enormously costly. What's needed is a mission design with the least amount of new development we can get away with. Such a plan would let us concentrate energies on the most important mission aspects: learning how to use lunar resources to support space flight.


Polar Ice
NASA

A HUGE RESERVOIR OF WATER ICE lingers in permanently shadowed regions at the Moon's south pole. The ice can provide hydrogen and oxygen to fuel spacecraft as well as air and water for future lunar inhabitants. NASA; ILLUSTRATION BY PAT RAWLINGS

The Office of Exploration at NASA's Johnson Space Center in Houston, Texas, has devised a clever architecture for lunar return that uses the Space Shuttle, augmented by existing expendable boosters. Thus, right from the start, it eliminates one of the biggest costs, the demand for a new launch vehicle.

> Returning to the Moon can – in truth, must – be done on a time-scale similar to political terms of office: four to six years.

The Johnson plan uses existing Delta IV expendable boosters to deliver the cargo elements of the lunar return to low Earth orbit: a lander, a habitat, and a transfer stage. Assembled into a package in Earth orbit, these items are then sent to a point in space about 80 percent of the way to the Moon. This point, called the Moon-Earth Lagrangian point 1 (L1 for short), is dynamically stable. It orbits Earth with the Moon such that it appears fixed in space from both bodies. Its placement relative to the two worlds lets us sit tight and wait for favorable alignments of these bodies and the Space Station during various phases of the mission.

As Apollo showed, direct flight from Earth to the Moon involves high velocities, short travel times, and loads of fuel. But with the L1 plan there's no need for speed. Cargo rockets can use innovative low-thrust technologies such as ion drives (used on the Deep Space 1 probe) to make long, spiraling trips out to L1. The journey there might take several months, gradually passing through the intense radiation belts that surround Earth.

The crew, however, would be launched separately. From Earth orbit they'd use a chemically fueled vehicle for a quick transfer to the L1 depot, taking just a few days to get there to avoid lingering in the radiation belts. The crew then moves into the lunar lander and habitat vehicle, continues on to the Moon, descends to the surface, and begins exploring.

The preferred landing site lies near the Moon's south pole, the most attractive spot for both science and operations. The goal of the mission is to build a manned base where we can learn to mine lunar resources on ever-larger scales. Each trip brings new components to the surface, and the size and capability of the lunar outpost grows over time.

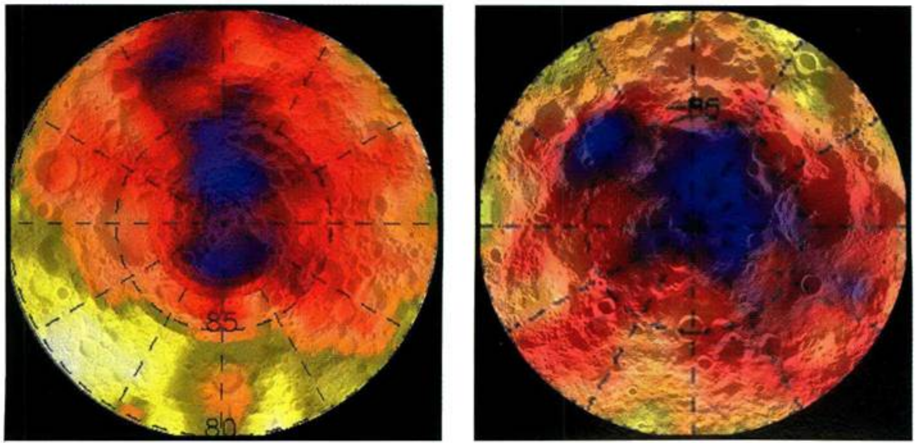
On return, the L1 depot provides a safe haven for the crew while they wait for the orbital plane of the Space Station to align with the trajectory of the return vehicle. Rather than entering the atmosphere directly and landing as Apollo did, the crew's return craft would skim the atmosphere, using friction to brake into orbit for rendezvous with the Station. Refueled, the vehicle would remain available for the next mission out to L1.

This architecture offers important benefits. No new heavy-lift booster is needed. We conduct the lunar mission from the Space Station and return to it afterward, making the Station an essential component of the migration into the solar system. Placing a staging depot at the L1 point makes it easy (in terms of energy) to go to the Moon — and it's almost as easy to go nearly anywhere else in the solar system, too. Using ion-drive propulsion for cargo vehicles pushes technology but doesn't require any great leaps. Technical innovations will emerge as a byproduct of the program, but the architecture doesn't depend on them.

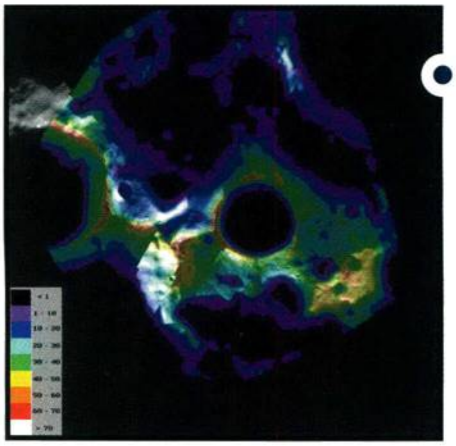
Space scientists often disparage the Shuttle and Space Station, but they play a key role in this plan. The reason: money. The costs of people and infrastructure almost completely dominate the price of space flight, and creating a new manned launch system would be enormously expensive. Since the Shuttle and the Space Station already exist, it makes sense to use them as much as possible and focus new efforts on finding, processing, and using lunar resources.

Reasons to return now

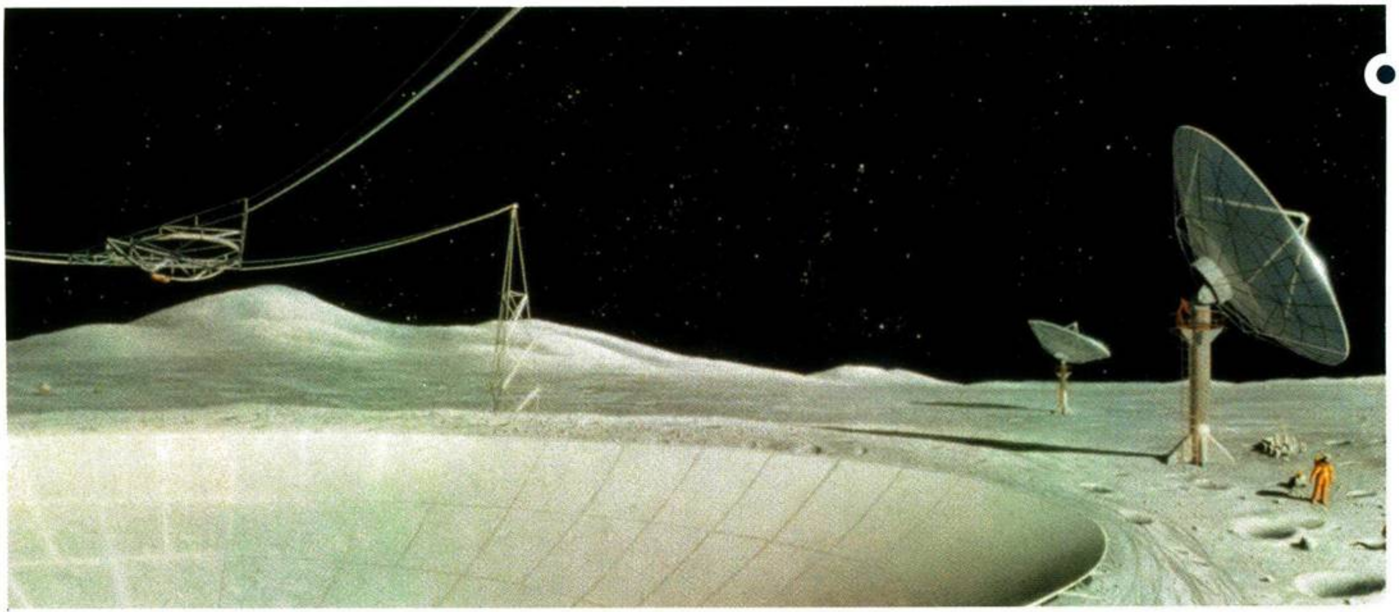
This mission plan makes sense from technical and fiscal perspectives. But does it make political sense? After all, no large-scale project will get funded by the federal government without a solid



THE MOON'S POLES harbor vast quantities of water ice in craters where the Sun never shines. These mosaics from the Clementine spacecraft show the Moon's north pole (left) and south pole (right). The blue zones trace the extent of ice found by the Lunar Prospector spacecraft. NASA/BMDO



SUNLIGHT AT THE SOUTH POLE ranges from nonexistent in deep craters to nearly continuous on a sliver of the rim of the crater Shackleton. NASA



THE FAR SIDE OF THE MOON offers the best vantage point in the solar system for astronomers studying radio emissions from deep space. No other location remains totally shielded from the electromagnetic noise streaming from our home planet. NASA; ILLUSTRATION BY PAT RAWLINGS

political rationale. Here's where the picture grows murkier.

The history of the United States shows that only two kinds of big engineering projects enjoy long-term funding stability: those related to national defense (the Panama Canal, the Apollo program) and those that build and maintain the economic infrastructure (the Tennessee Valley Authority, the interstate highway system).

Unfortunately, neither the search for worlds around other stars nor a search for extraterrestrial life fits these categories. So it's unlikely that pure science projects will be funded well enough to allow a great deal of human space flight. This outcome poses a constant threat for NASA. If people are not flying in space — an activity that crystallizes public support for the space program — NASA will wither away.

If you ask anyone at NASA what their next big goal is, they'll answer "Mars." NASA scientists have detailed plans for exploring the Red Planet, culminating in a series of robotic sample-return missions late in the 2010s as prelude to human journeys. Advanced studies focus almost exclusively on manned Mars missions and on the search for evidence of former or existing martian life.

The problem is, a human mission to Mars won't happen. No matter how it has been approached, scaled-back, or reinvented, the reality is that such missions cost *hundreds* of billions of dollars and need time spans lasting decades. The national budget simply won't stretch for a project of this magnitude.

Can international cooperation make Mars affordable? Our experience with the Space Station suggests not. Large-scale international missions invest more resources in bureaucracy than in space hardware. Consensus management and organizational in-fighting produce delays and increase costs, and projects become hostages to other countries' budget fights, too. The result is a mission that's less capable, more expensive, and more delayed than if it had been done from the start by one nation with a vision.

But even a space program undertaken by a single nation has no guarantee of success. The best programs are those undertaken with clear aims and well-chosen goals, and which are done under some schedule pressure. They also must have a clear political rationale. To get long-term funding, a technical project must relate to some national priority, and it must produce a payback on time-scales roughly equal to political terms of office — that is, four to six years.

Mars is out of the question under these conditions. But a lunar return is achievable within five years, at a cost one-tenth that of a manned Mars mission. Moreover, by developing the capability to operate on the Moon, we gain routine manned access to all levels of Earth orbit, including geosynchronous orbit. (This is where a satellite circles once every 24 hours, remaining fixed in the sky over a given point on Earth.)

At 23,000 miles high, geosynchronous orbit is where all of Earth's communication satellites reside. The ability to send people there is important because the next generation of communication satellites will need to be gigantic, complex machines, requiring megawatts of power. Too expensive to abandon when they malfunction, such satellites will require occasional maintenance.

Going to the Moon to mine its abundant water ice for use as rocket propellant will provide routine access to geosynchronous orbit and other zones of near-Earth space. With this capability, worth trillions of dollars, we can build, maintain, and operate the service satellites of the new century.

Unlike Mars, a return to the Moon provides us an excellent opportunity to accomplish important national goals. This mission will aid our national security by giving the United States access to valuable lunar resources (our first, off-world "El Dorado"). It will also boost our expanding economic infrastructure by teaching us how to use all the orbital levels of near-Earth space. A lunar return ties the space program to important national priorities — and it gives NASA an exciting, vigorous mission that paves the way to the planets beyond. ◼

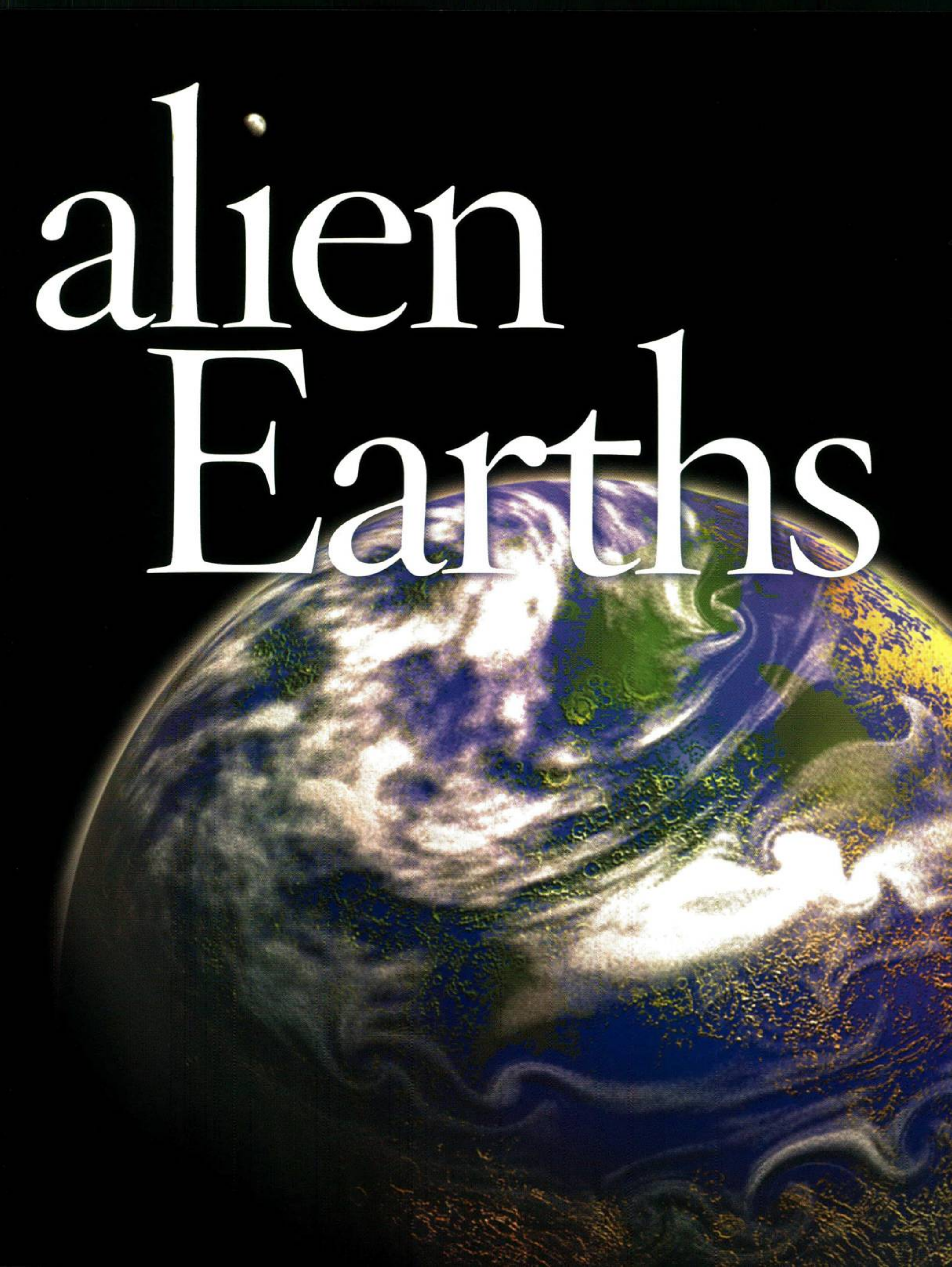
Searching for

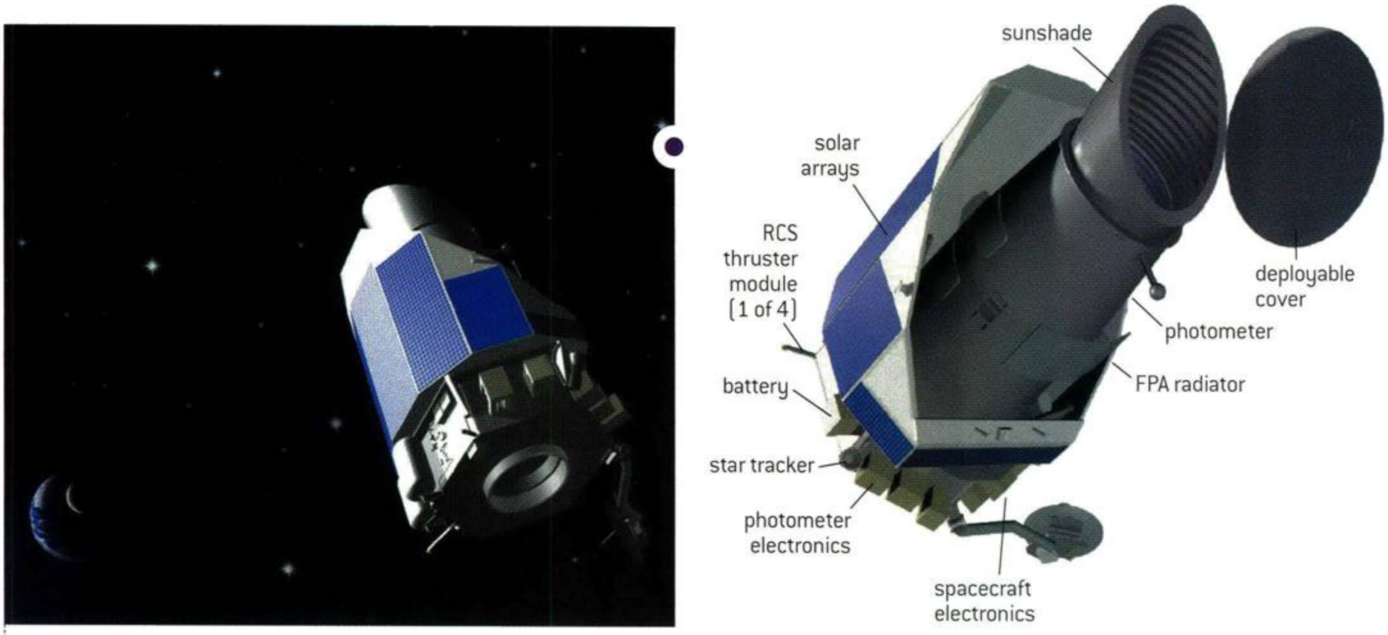
Scientists think we may be only a decade away from finding planets like ours in other star systems — and perhaps even detecting signs of life. /// BY RAY JAYAWARDHANA

As the Galileo spacecraft flew past our planet in 1990 for a little gravitational kick on its way to Jupiter, it attempted to answer an intriguing question: Is there life on Earth? Carl Sagan, who persuaded NASA to train Galileo's instruments on our own "pale blue dot," didn't intend this as a tongue-in-cheek question. For him it was a serious scientific query, with far-reaching implications. He wanted to investigate whether signs of life on Earth can be detected unambiguously from afar. ☾ Sagan's quest has gained renewed interest and urgency with the discovery of planetary systems around more than 100 nearby stars and improved prospects of searching for alien life. To be sure, all the exoplanets found to date — discovered through their gravitational tugs on the parent star or by the dimming of starlight as they pass in front of it — are probably gas giants like Jupiter and Saturn. These are unlikely to harbor life as we know it. But, the argument goes, some of these alien Jupiters might be accompanied by lower-mass brethren, perhaps even distant counterparts to Earth. A repeated dip in a star's brightness by a mere one part in ten-thousand could signal one's presence. Two satellite observatories now being built, NASA's Kepler and the European Space Agency's Eddington, will look for just that signature of earthlike planets around 100,000 stars in our neighborhood.

GALILEO SOUGHT SIGNS OF LIFE ON EARTH (above) during its 1990 flyby. The verdict: Spacecraft can detect life-signs from afar. NASA/JPL Within the next decade, astronomers think they might find evidence of exotic earthlike planets (opposite page), and maybe extraterrestrial life. *ASTRONOMY*: TOM FORD

alien Earths





NASA'S KEPLER MISSION will seek earthlike planets by looking for a tiny dip in brightness caused by the planet as it passes in front of its parent star. NASA

Finding an Earth-sized planet is one thing, but detecting signs of life is quite another. Beyond Kepler and Eddington, both NASA and ESA plan to follow up with more ambitious spaceborne observatories. NASA's Terrestrial Planet Finder (TPF) and ESA's Darwin are designed to take pictures of an extrasolar Earth. More importantly, both TPF and Darwin are expected to break down the planet's feeble light into a spectral rainbow of colors to look for signs of life in its midst. The builders of these missions hope to achieve this remarkable feat by canceling the blinding glare of the planet's parent star. They'll do this either by combining observations from multiple telescopes in an array or, using a different kind of spacecraft and telescope, by blocking the star with a cleverly designed opaque mask embedded within the optical system.

> Any curious aliens who cared to inquire about us would know that life has been present on Earth for a very long time.

Given the technological complexity and the high price tag of the task, the two space agencies may eventually pool their efforts and resources to launch one joint mission rather than two competing observatories.

While the launch of Terrestrial Planet Finder/Darwin is about a decade — and a number of technological milestones — away, several groups of scientists are already busy at work to define exactly what fingerprints of life it should search for. In that monumental undertaking, they are guided by the one known example of a life-bearing planet — Earth.

Sagan's experiment with Galileo provided a reassuring start. The probe's instrument suite detected several telltale signs of a planet teeming with life. Galileo found an atmosphere rich in oxygen that contains higher levels of methane than would be expected from geological activity alone. It also registered traces in the terrestrial spectrum characteristic of the chlorophyll molecule, which plays a key role in the photosynthesis of plants.

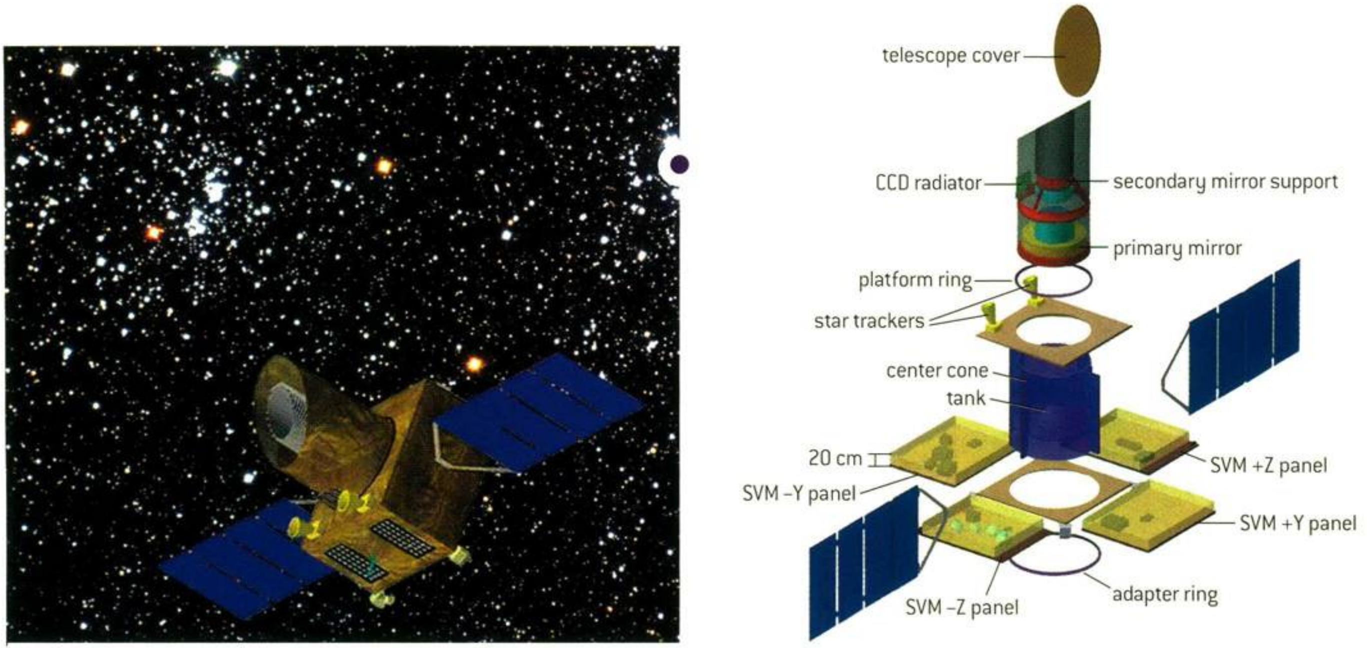
Recently, two teams of astronomers repeated Galileo's observations with an interesting twist. One team was led by Wesley Traub of the Harvard-Smithsonian Center for Astrophysics and Neville Woolf of the University of Arizona, the other by Luc Arnold of the Observatoire de Haute Provence and Jean Schneider of the Paris Observatory in France.

Not having a spacecraft far enough away, they took spectra of earthshine — the glow of sunlight reflecting from our planet and falling on the unlit part of the Moon. While Galileo observed only a limited area of Earth's surface, earthshine yields a spectrum integrated over the entire visible face of Earth, a view more akin to what we'd see of a distant alien world. Sure enough, both the American and French teams identified spectral features due to water vapor, oxygen, and ozone.

As Traub points out, these signs of life would have been detectable for significant fractions of Earth's history, much longer than it has harbored intelligent life. Our planet has maintained an oxygen-rich atmosphere for some two billion years, and its spectrum has exhibited chlorophyll's traces since the first land plants evolved 500 million years ago. As Woolf puts it, "Any advanced civilization that cared to inquire would know that life has been present on Earth for a very long time."

Next, their team would like to determine how the spectrum of earthshine changes as different areas of the planet rotate into view, and as cloud cover changes. Eric Ford and Edwin Turner

Ray Jayawardhana *is an assistant professor of astronomy at the University of Michigan. He explores the origin and diversity of planets using some of the world's largest telescopes.*



ESA'S EDDINGTON MISSION will hunt for earthlike planets using a technique similar to that of Kepler, as well as study the varied compositions of stars. ESA

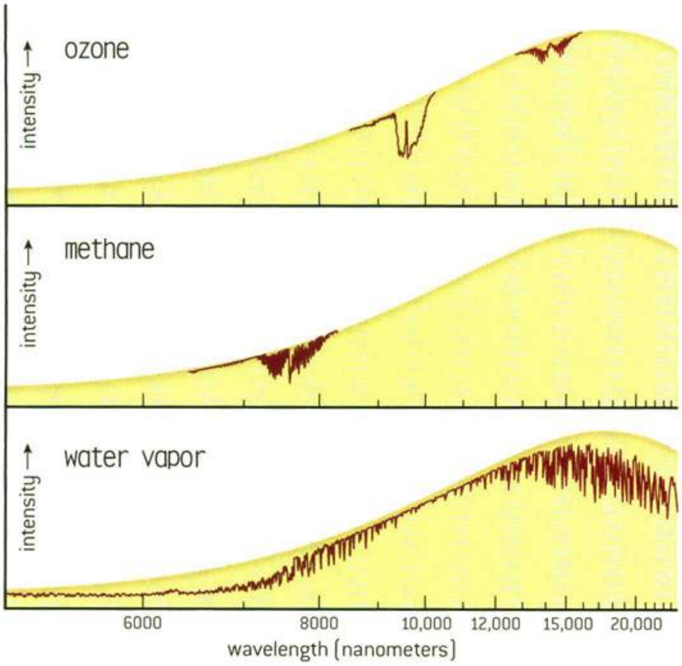
of Princeton University and Sara Seager of the Carnegie Institution of Washington have already calculated models of variations that might be seen as Earth rotates.

Chemistry tells the tale

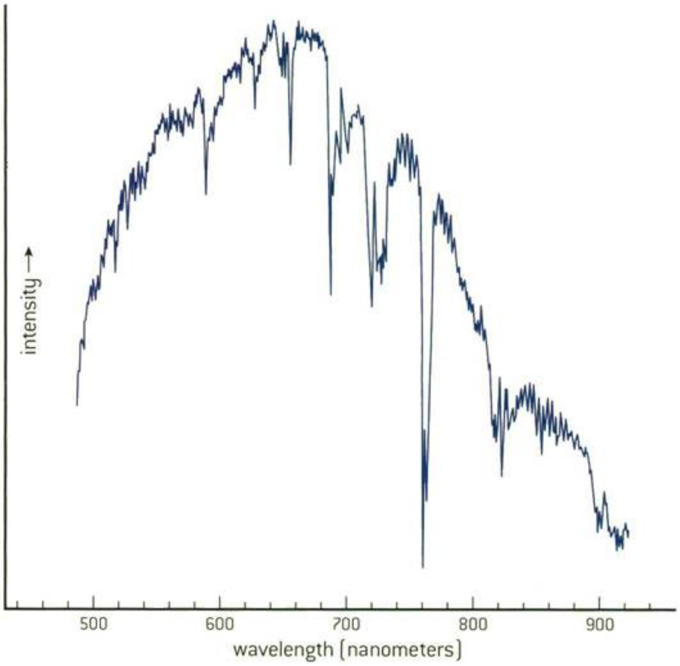
These early observations and calculations of life signs are paving the way for serious planning for the Terrestrial Planet Finder and Darwin missions. Just last year, NASA's Jet Propulsion Laboratory (JPL) commissioned a group of scientists, including Traub, Woolf, and Seager, to evaluate the relative significance of various planetary bio-markers and to recommend observing strategies for TPF.

Not surprisingly, among the most reliable bio-markers identified by the TPF study are oxygen molecules (O_2), a byproduct of photosynthesis by plants on Earth, and its cousin, ozone (O_3), which is actually easier to detect in a spectrum even though it is much less abundant. Oxygen molecules do not stay single for long; they combine easily with other compounds, such as silicon in rocks, in a process known as oxidation. "So, to sustain a large amount of oxygen in a planet's atmosphere, there needs to be continuous production," Traub explains. And life as we know it is an excellent source of oxygen.

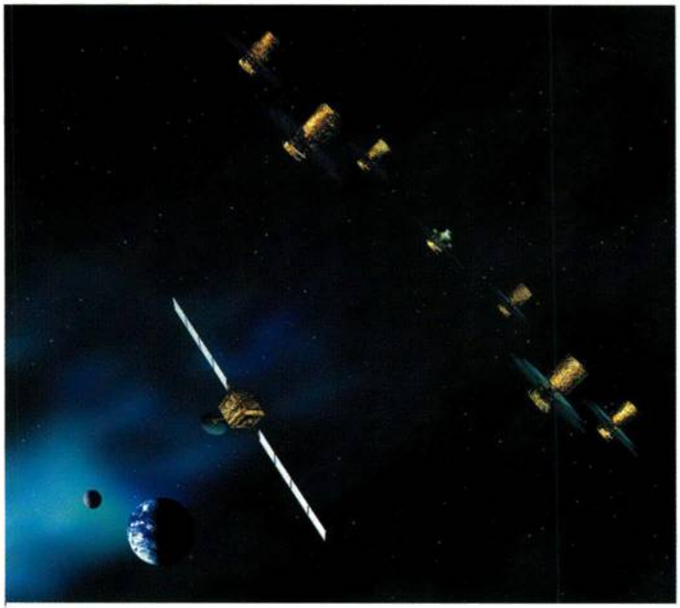
Does that mean the detection of oxygen or ozone in a planetary spectrum is a foolproof indication of life? Not necessarily,



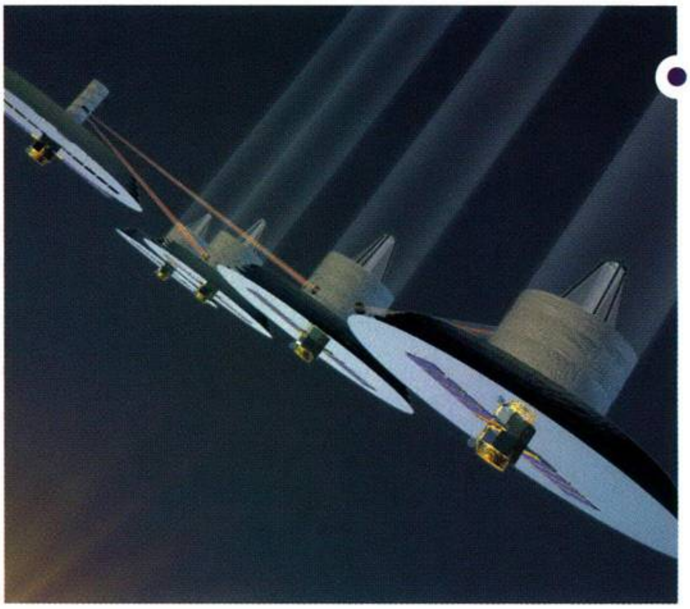
LIFE'S SPECTRAL SIGNATURE will likely consist of a mixture of ozone, methane, and water vapor. The calculated spectra here show the effects of these trace gases on the thermal spectrum of an alien Earth. W. TRAUB (CFA)



THE SPECTRUM OF EARTHSHINE clearly shows molecular oxygen (the lines near 690 and 760 nanometers) and water vapor (the band between 710 and 730 nanometers) superposed on the solar spectrum. N. WOOLF (UNIV. OF ARIZONA) ET AL.



ESA'S DARWIN MISSION will attempt to detect the signature of life on other worlds by examining the spectra of distant exoplanets. ESA



NASA'S TERRESTRIAL PLANET FINDER will look for the spectral signature of life either with an interferometer array (above) or a coronagraph. NASA

says James Kasting of Pennsylvania State University, another member of the Terrestrial Planet Finder working group on bio-markers and a renowned expert on planetary atmospheres. "We know of non-biological processes that can also result in an oxygen-rich atmosphere," he points out. One such example is Venus with its runaway greenhouse effect. The breaking up of water molecules (H_2O), followed by the quick escape of hydrogen into space, continuously replenishes the oxygen in its atmosphere. Another example would be an ice-covered planet massive enough to hold its oxygen. The frozen crust would prevent the oxygen from interacting with minerals on the ground, thus retaining it in the atmosphere. Although scientists need to guard against such false positives, the identification of either oxygen or ozone in an exoplanet spectrum would be "very exciting and significant," as the Terrestrial Planet Finder bio-marker report concludes.

Chris Chyba, a planetary scientist at the SETI Institute in Mountain View, California, is one who believes that unambiguous detection of life via remote sensing will be extremely difficult. Separating true bio-markers from those that could also arise from non-biological processes is far from trivial, he thinks, especially if scientists have little information about the surface conditions of a planet. "But that doesn't mean we shouldn't be trying to do it," says Chyba.

/// CHEAPER AND FASTER SEARCHES

THE DETECTION OF LIFE on an extrasolar Earth will probably have to await the launch of the Terrestrial Planet Finder spacecraft some ten years from now. But if we are extremely lucky, there is a tiny chance of doing it much sooner and a lot more cheaply, says Michael Jura of the University of California-Los Angeles. In fact, current ground-based telescopes are already up to the task, provided many other "ifs" are satisfied.

When a Jupiter-like planet passes in front of a sunlike star, as seen from Earth, it covers about 1 percent of the star and causes an equivalent dip in brightness. Three such transits of extrasolar planets — HD 209458b, OGLE-TR-56b, and OGLE-TR-3b — have already been observed.

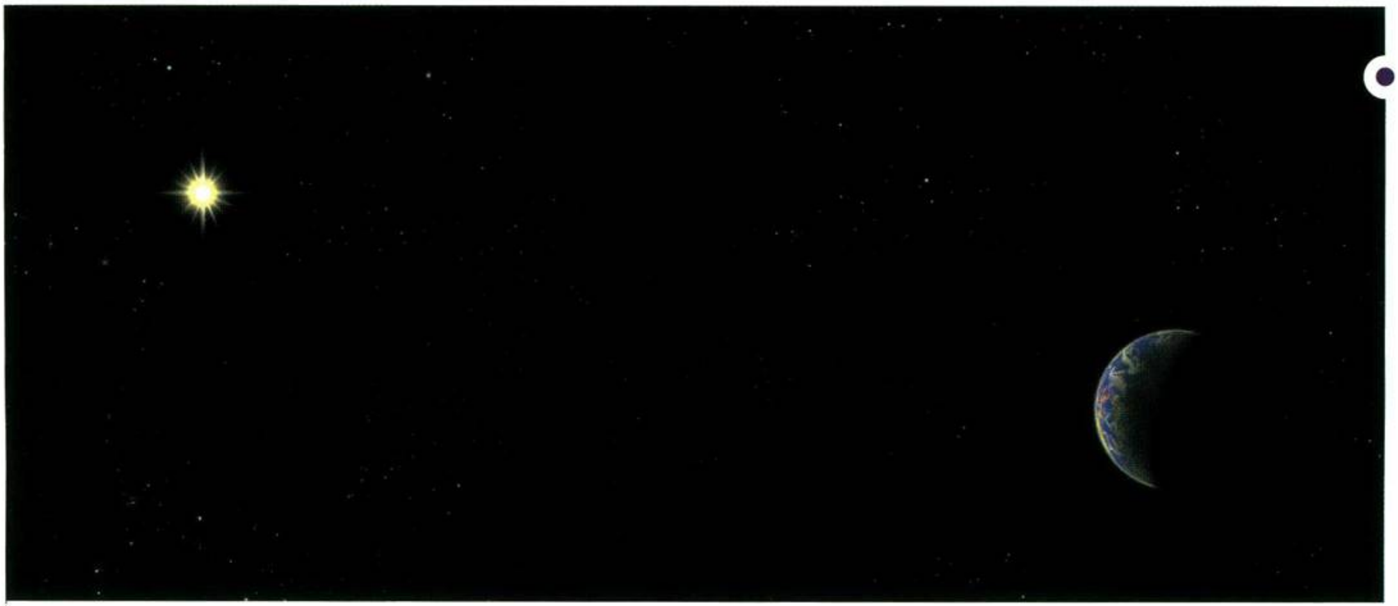
But what if the parent star were much less massive than the Sun, say a tenth of a solar mass? Such a star, called a late-M dwarf, has a diameter about as small as Jupiter. If such a star harbors a Jupiter-like planet in a tight orbit that happens to be seen edge-on from Earth, we might see the host star undergo a total eclipse, Jura points out.

What's more, if the hypothetical system also included a second planet, then its feeble reflected light might peek through during the total eclipse. "That would give us a chance to measure its colors in order to look for signatures of life," says Jura, who is well regarded among his colleagues for thinking outside the box. Of course, as Jura himself concedes, the chances of all the conditions being just right are rather small. To begin with, astronomers do not know how common — or rare — it is for low-mass stars to harbor close-in Jupiters. Current planet searches using radial velocity measurements have concentrated on sunlike stars, rather than their punier cousins.

That's partly due to an Earth-centric bias, but also because stars with a lower mass are significantly fainter, making precise spectral observations more difficult. A new radial velocity survey specifically targeting low-mass stars could provide the first clue. Paul Butler of the Carnegie Institution, Geoffrey Marcy of the University of California-Berkeley, and Fred Adams of the University of Michigan are using the 6.5-meter Magellan telescope in Las Campanas, Chile, to survey 100 M-type dwarfs in search of Jovian planets. It's also possible that one of more than 20 ongoing planet-transit searches around the world will turn up a near-total eclipse of a low-mass star.

For now, Jura guesses that perhaps only one out of every 100,000 low-mass stars would undergo a total eclipse by a close-in giant planet. Cataloging and monitoring that many low-mass stars in search of an eclipsing Jupiter with a terrestrial sister is a daunting task.

"While the odds of success are highly uncertain and the observations are technically challenging, at least we don't need to wait a decade to start the search for extrasolar life," Jura argues. — R. J.



LIFE-BEARING EXOPLANETS are most likely to form around stars with a mass not too different from the Sun's. Although a terrestrial planet could condense out of debris left over from the formation of a low-mass star, such a world would be unlikely to support life as we know it. *ASTRONOMY*: TOM FORD

Perhaps the most convincing evidence for life on a distant world would be finding multiple bio-markers. One possibility would be to detect oxygen or ozone along with liquid water, coupled with high levels of carbon dioxide, exhaled by animals, or methane, released on Earth by anaerobic bacteria in rice paddies, peat bogs, and tundra. "The general consensus is that if we find several of these bio-markers simultaneously, it will be a very strong indicator of life's presence," says Malcolm Fridlund, Darwin Project Scientist at ESA. Of course, finding those signatures would not distinguish between primitive bacteria and complex aliens. That would require a different kind of sign.

Alien Earths — with a twist

Some scientists worry that life elsewhere would be so fundamentally different that bio-markers identified for terrestrial life might be all but meaningless. Traub agrees that "there's great danger in generalizing from one example." On the other hand, he argues, life anywhere may have at least a few things in common. "Despite all our speculations, we haven't come up with a convincing alternative to water and carbon chemistry as a basis for life. So I see no reason to go looking for more exotic things, at least for now," he explains.

Of course, there could well be many forms of life that would not register on a planet's overall spectrum, such as bacteria underground or in deep ocean vents. And it may be difficult to detect bio-markers at the surface — like chlorophyll on Earth — if much of the planet were covered by clouds.

Coming up with life-bearing worlds different from the present-day Earth is one of the goals of the Virtual Planetary Laboratory, a NASA-funded multi-million dollar project led by JPL's Vikki Meadows. Her team consists of 28 researchers from disciplines as varied as statistics and biochemistry. They are developing sophisticated computer simulations of the environments and spectra of a broad range of rocky planets with, and without, living organisms. "We are modeling life as we know it — but not necessarily in the balance we have here on Earth," she says.

Meadows' plan is rather ambitious: to construct the first models of terrestrial planets that combine the effects of — and the interplay between — stellar heat, climate, chemistry, geology, and biology. Once those models are in place, she and her colleagues plan to validate them first by comparison with Venus, Earth, and Mars. Later, they will reconstruct what the early Earth would have looked like from a distance, before its atmosphere became rich in oxygen. Eventually, the researchers plan to "play around with the recipe," trying different combinations of size, composition, and temperature to investigate the effects of these on life and vice versa. To explore the range of temperature at which life might exist, for example, "we'll model everything from frozen hells to burning hells," says Meadows.

That's all part of the homework scientists need to complete in preparation for the day when we are able to catch the faint glow of a distant world and decipher its signs of life. When that day comes, chances are that we will see our own planet — and ourselves — in a whole new light.

{ In looking for planets with the right temperature for life to exist, scientists are modeling everything from frozen hells to burning hells.

To learn more about the NASA and ESA space missions designed to search for planets and life, visit http://www.astronomy.com/toc

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We've upgraded our EZ Finder with a new design and improved bracket—at a lower price. This aiming device superimposes a LED-powered red dot in a wide 10° field of view, showing exactly where the telescope is pointed. Now with a new bracket that fits the quick-release mounting base on many Orion telescopes.

$34.95

New!

Deluxe Laser Collimator

DANGER
LASER RADIATION
AVOID DIRECT EYE EXPOSURE
LASER DIODE
CLASS IIIA LASER PRODUCT

An improvement to our original LaserMate collimator. The "rear view" port allows one-step precision collimation. Now you can collimate without having to leave the mirror cell to check the alignment. Great for long tube Newtonian reflectors. Only 5-3/4" long.

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Sm **$22.95** Med **$32.95** Lg **$42.95**

Atlas™ Heavy-Duty Equatorial Mount

Our beefiest and most advanced mount offers amateur astronomers a rock-stable platform at a price unheard of before. Supports telescope tubes of up to 40 lbs. Atlas comes with dual internal DC stepper motor drives, 3" setting circles, polar alignment scope, 2" stainless-steel tube legs, and two 11 lbs. counterweights. Weight (without counterweights) 54 lbs.

$799

RockStable™ Anti-Vibration Pads

Special visco-elastic material reduces vibrations from wind and other sources. Ideal for both visual astronomy and astrophotography. Sold in sets of three.

$48.95

EYEPIECES

Highlight™ Plössl Eyepieces

Like the Sirius Plössl line, HighLight eyepieces offer a generous 50° field of view (43° for the 40mm) and crisp, sharp images. But the HighLight's 4-element optics are not just fully coated or multi-coated, but fully multi-coated. That means that every air-to-glass lens surface is multi-layer coated for the highest possible light transmission and better contrast. Rubber eyeguards.

FULLY MULTI-COATED!

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm	**$54.95**
32mm, 40mm	**$59.95**

Expanse™ Wide-Field Eyepieces

With their 66° apparent field of view, our Expanse wide-field eyepieces will definitely turn up the Wow! factor in your deep-sky observing experiences! Imagine taking in objects like the Andromeda Galaxy, the Double Cluster, or the star clouds in Sagittarius in one sweep! With an Expanse in your focuser, you can! Fully coated, rubber eyeguards.

6mm, 9mm, 15mm, 20mm **$49.95**

Sirius™ Plössl Eyepieces

You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. Fully-coated optics, rubber eyeguards.

1.25"

6.3mm, 7.5mm, 10mm, 12.5mm, 17mm, 20mm, 26mm	**$39.95 each**
32mm, 40mm	**$44.95 each**

Epic™ ED-2 Eyepieces

Our new ED-2 eyepieces are made of "Extra-low Dispersion" optical glass that boasts superior refractive properties. Epic 1.25" eyepieces feature a six-element lens design in which two of the elements are crafted from ED glass. Each provides luxurious 20mm eye relief, reduced chromatic aberration and a wide 55° apparent field.

25mm, 22mm, 18mm, 14mm, 12.3mm, 9.5mm, 5.1mm, 3.7mm

$69 ea.

NEW 18MM & 25MM

BINOCULARS

7-15x35 Venture™ Zoom Binoculars

A wonderfully compact, all purpose instrument with 35mm objective lenses and a 7X to 15X continuous zoom range.

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8-20x50 Venture™ Zoom Binoculars

Finally, an astronomy binocular with continuously variable magnification—from 8x to a whopping 20x!

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Mini Giant™ Binos

Compact astro binocs that show you the light! Fully multi-coated optics, BAK-4 prisms. Long eye relief (8x56: 18mm, 9x63: 26mm, 12x63: 17.5mm, 15x63: 19mm). Easily hand-holdable, but also tripod adaptable.

8x56	5.8° field	**$159**	**12x63**	4.7° field	**$199**
9x63	5.0° field	**$189**	**15x63**	3.7° field	**$199**

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Vista™ 50mm

Featherlight high-performance binoculars. High-index BAK-4 prisms and fully multi-coated optics for high-fidelity images. Soft leatherette covering. Tripod adaptable.

8x42	6.5° field	**$189**
7x50	6.0° field	**$199**
10x50	WA 5.3° field	**$199**

MegaView™ 80mm Binoculars

Sale!
SAVE $50

Premium giant binoculars with high-power optics and cross-reinforced aluminum body and sliding tripod mounting post for optimum balance. Fully multi-coated 80mm lenses with BAK-4 prisms. Long eye relief.

15x80	3.5° field	**$429**
20x80 WA	3.5° field	**$439**
30x80 WA	2.3° field	**$449**

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BY MARTIN RATCLIFFE AND ALISTER LING

JUNE 03

The long-awaited apparition of the Red Planet finally kicks into high gear.

Goodbye Saturn, hello Mars

Mars will be grabbing headlines over the next several months as it cruises toward its closest approach to Earth in more than 50,000 years. Observers already are following the dark markings on its ruddy surface. But while Mars beckons, don't give up on Saturn just yet. By the time it reappears in the morning sky for August star parties, the rings will be starting to close from their current maximum.

Saturn appears at its best in evening twilight at the start of June, before it sinks too low. Closer to the horizon, Earth's thick atmosphere scrambles the view of the magnificent rings and makes the moons harder to see. In a mere six years, Saturn's rings will be tipped edge-on from our point of view and the Ringed Planet will appear ringless.

Jupiter won't take long to follow Saturn into the murk. A fantastic season of mutual eclipses and occultations of its moons is coming to a close. The best event this month for North American observers starts at 11:55 P.M. EDT (8:55 P.M. PDT) on the night of June 7/8, when Ganymede eclipses Io. Io dims by 64 percent when the eclipse peaks six minutes later. Also watch Jupiter on the nights of June 1/2, 14/15, and 28/29, when all four Galilean moons lie on one side of the planet.

THE RED PLANET RETURNS to glory this month, appearing bigger and brighter than it has in two years. NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

Earth's summer solstice occurs at 3:10 P.M. EDT on June 21. This is the date when the Sun appears highest in the sky at local noon for observers north of the Tropic of Cancer. South of the equator, this day marks the winter solstice. Remember that the seasons result from the tilt of Earth's axis with respect to its orbit, not our planet's distance from the Sun. In fact, Earth will reach its farthest point from the Sun on July 3/4.

Mars grows bigger and brighter this month as it heads toward a spectacular opposition in late August, when it will span 25.1″ and shine at magnitude –2.9. It comes as a surprise to many first-time observers, but surface detail on the Red Planet can be pretty subtle and unimpressive. The only way to beat this is to start training your eye and brain now — it really works. Mars appears best as dawn nears because it then lies higher in the sky. Watch it brighten dramatically this month, climbing from magnitude –0.7 to magnitude –1.4, the equal of Sirius. In comparison, Venus blazes at magnitude –3.9.

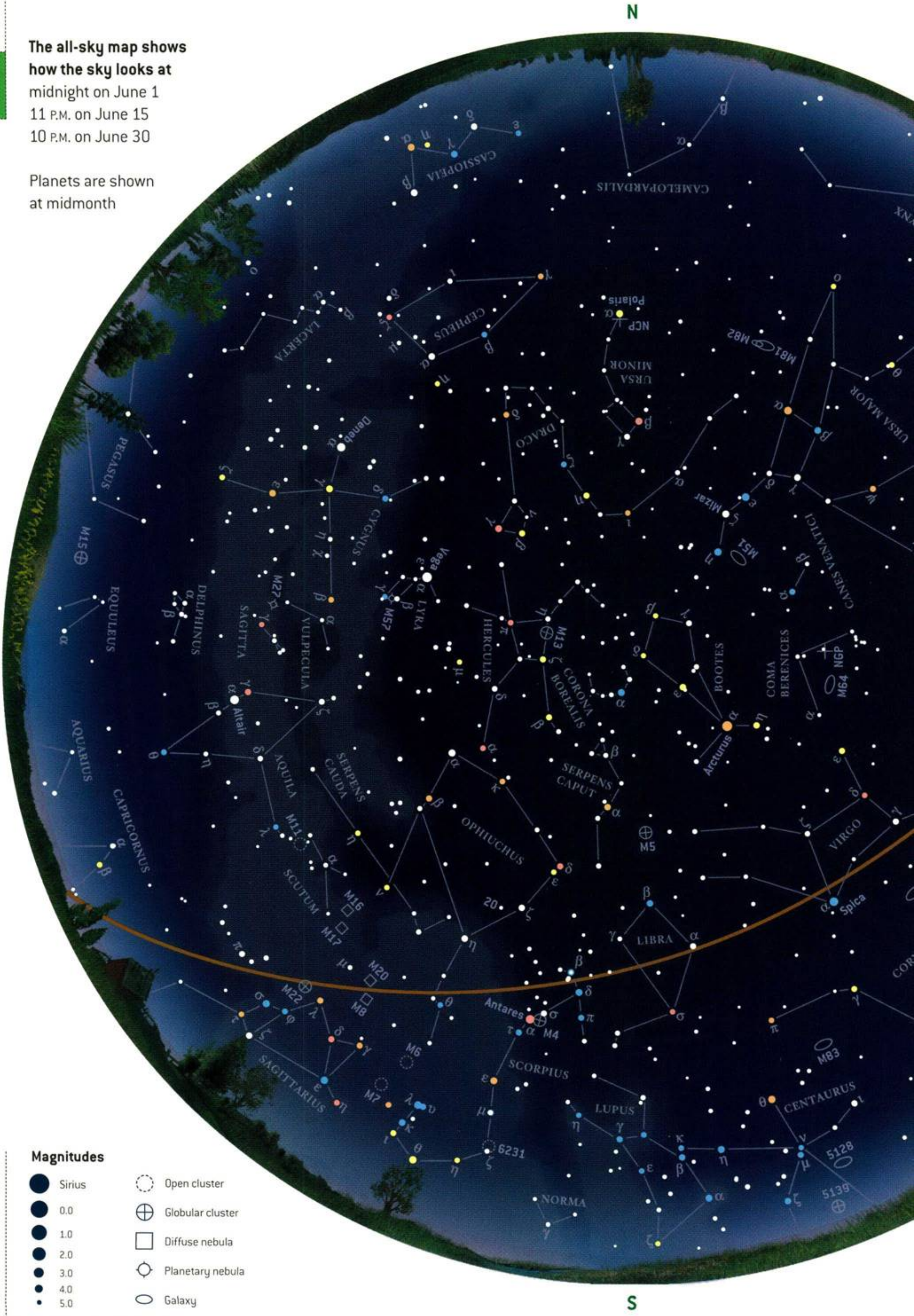
Venus lies in the morning sky, but low in the twilight as the sky brightens. Daytime observers can look forward to a neat telescopic event on June 21, when Mercury and Venus appear in the same eyepiece view. You'll need a clear blue sky to see the two pass slightly closer than the apparent size of the Moon.

Our Moon begins June as a slender crescent near Saturn, then appears as a fatter crescent to the right of Jupiter on the 4th. You might try making a multiple exposure every five to ten minutes to show the Moon slipping past Jupiter as the pair sets. After Full Moon on June 14, the waning Moon cruises under Mars on the morning of the 19th.

Pluto watchers rejoice! On June 9, the most distant planet forms an almost straight line with the Sun and Earth. This configuration is called opposition, when Pluto glows brightest at magnitude 13.8 and appears highest in the sky at local midnight. With a good chart and a lot of patience, you can snag Pluto in a dark sky at the start or end of the month. I recommend a 10-inch scope for beginners, but experts have bagged the frozen ball through scopes as small as 6 inches, patiently waiting for it to pop out of the background every few seconds.

The all-sky map shows how the sky looks at
midnight on June 1
11 P.M. on June 15
10 P.M. on June 30

Planets are shown at midmonth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LYN
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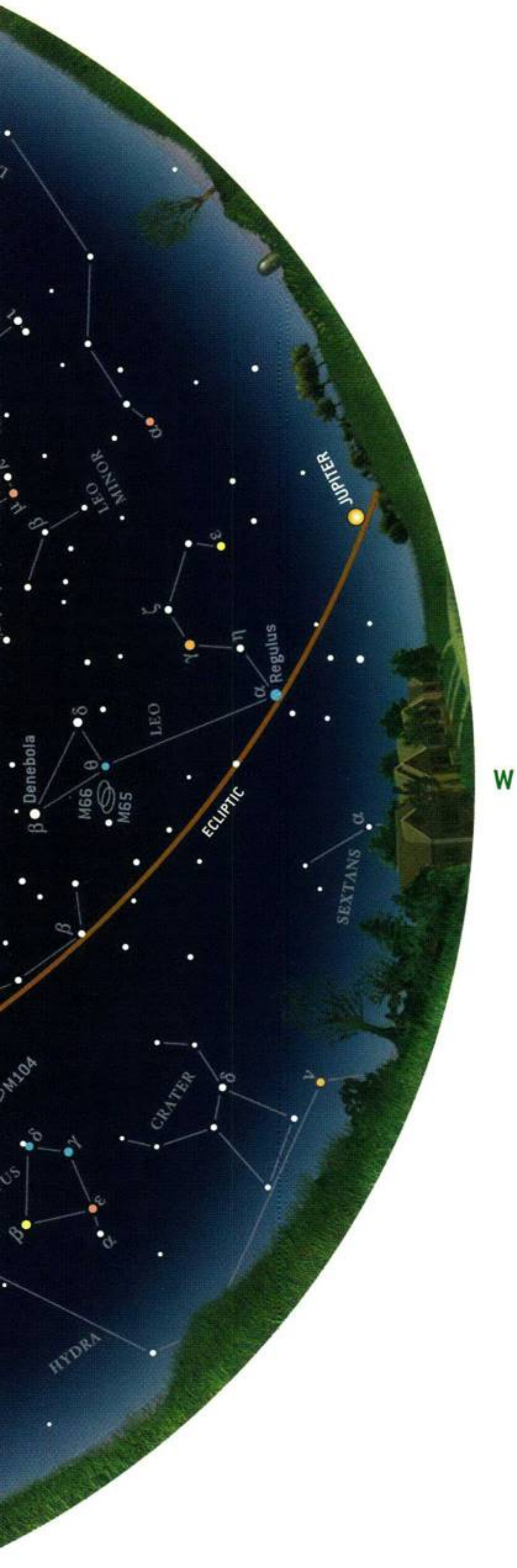
URSA MAJOR
DRACO
Deneb
PEGASUS
CYGNUS
Mizar
M51
CANES VENATICI
M15
EQUULEUS
DELPHINUS
SAGITTA
M27
VULPECULA
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Altair
AQUARIUS
AQUILA
SERPENS CAUDA
SERPENS CAPUT
Arcturus
CAPRICORNUS
M11
OPHIUCHUS
M5
VIRGO
SCUTUM
M16
M17
20
LIBRA
Spica
COR
M22
M20
M8
Antares
M4
M6
SCORPIUS
SAGITTARIUS
M7
M83
CENTAURUS
LUPUS
6231
5128
NORMA
5139

Magnitudes

- ● Sirius
- ● 0.0
- ● 1.0
- ● 2.0
- ● 3.0
- ● 4.0
- • 5.0

- ◌ Open cluster
- ⊕ Globular cluster
- ☐ Diffuse nebula
- ⌖ Planetary nebula
- ⬭ Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions:
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sk


JUPITER
LEO MINOR
α
ε
μ
ζ
γ
η
α Regulus
LEO
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β Denebola
M66
M65
ECLIPTIC
SEXTANS
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CRATER
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α
HYDRA
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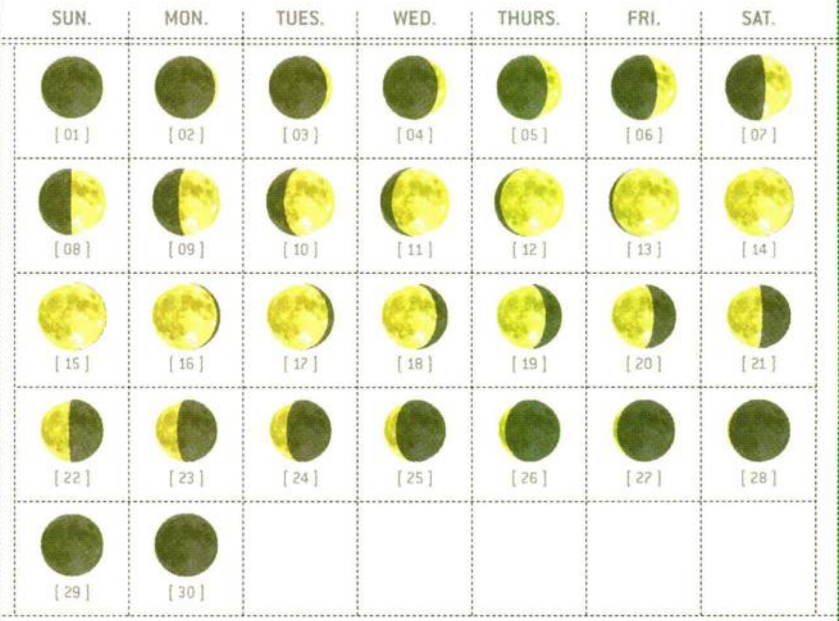
june 03


SUN.
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01 The Moon passes 4° north of Saturn, 5 P.M. EDT

03 Mercury is at greatest western elongation (24°), 2 A.M. EDT

05 The Moon passes 4° north of Jupiter, 2 A.M. EDT

07 First Quarter Moon is at 4:28 P.M. EDT

09 Pluto is at opposition, 5 P.M. EDT

10 Asteroid Victoria is at opposition, 1 A.M. EDT

12 The Moon is at perigee (223,958 miles from Earth), 7:17 P.M. EDT

14 Full Moon is at 7:16 A.M. EDT

17 The Moon passes 5° south of Neptune, 5 P.M. EDT

18 Venus passes 5° north of Aldebaran, 3 P.M. EDT

19 The Moon passes 1.7° south of Mars, 2 A.M. EDT

19 The Moon passes 5° south of Uranus, 4 A.M. EDT

Mercury passes 4° north of Aldebaran, 8 A.M. EDT

20 Asteroid Flora is at opposition, 3 P.M. EDT

Mars passes 3° south of Uranus, 7 P.M. EDT

Mercury passes 0.4° south of Venus, 10 P.M. EDT

21 Last Quarter Moon is at 10:45 A.M. EDT

Summer solstice is at 3:10 P.M. EDT

24 Saturn is in conjunction with the Sun, 10 A.M. EDT

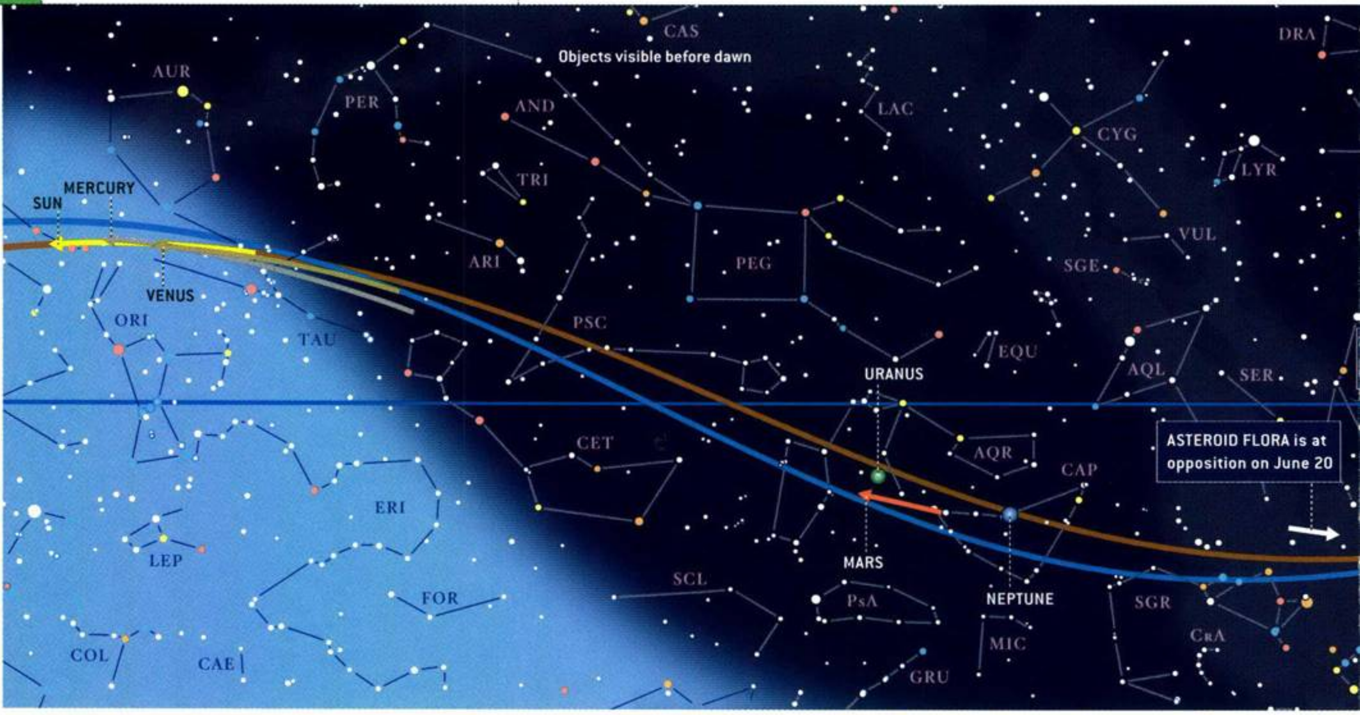
The Moon is at apogee (251,800 miles from Earth), 10:24 P.M. EDT

29 New Moon is at 2:39 P.M. EDT

orth, south, east, and west. To find stars above your

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and sc


CAS
Objects visible before dawn
DRA
AUR
PER
AND
LAC
CYG
LYR
TRI
SUN
MERCURY
VUL
ARI
PEG
SGE
VENUS
ORI
TAU
PSC
EQU
URANUS
AQL
SER
CET
AQR
CAP
ASTEROID FLORA is at opposition on June 20
ERI
LEP
MARS
SCL
FOR
PsA
NEPTUNE
SGR
MIC
CRA
COL
CAE
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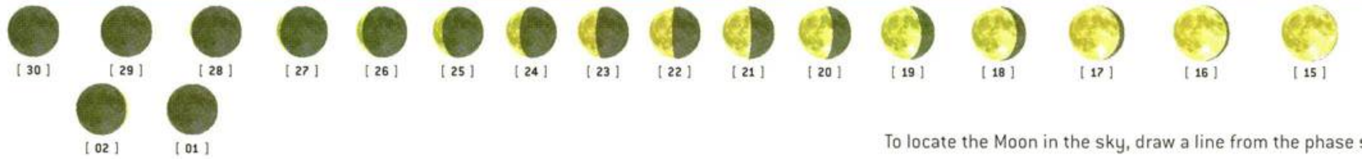
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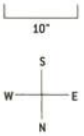
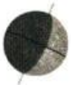
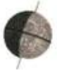
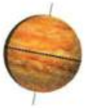
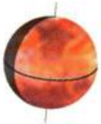
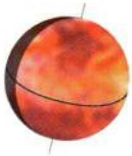
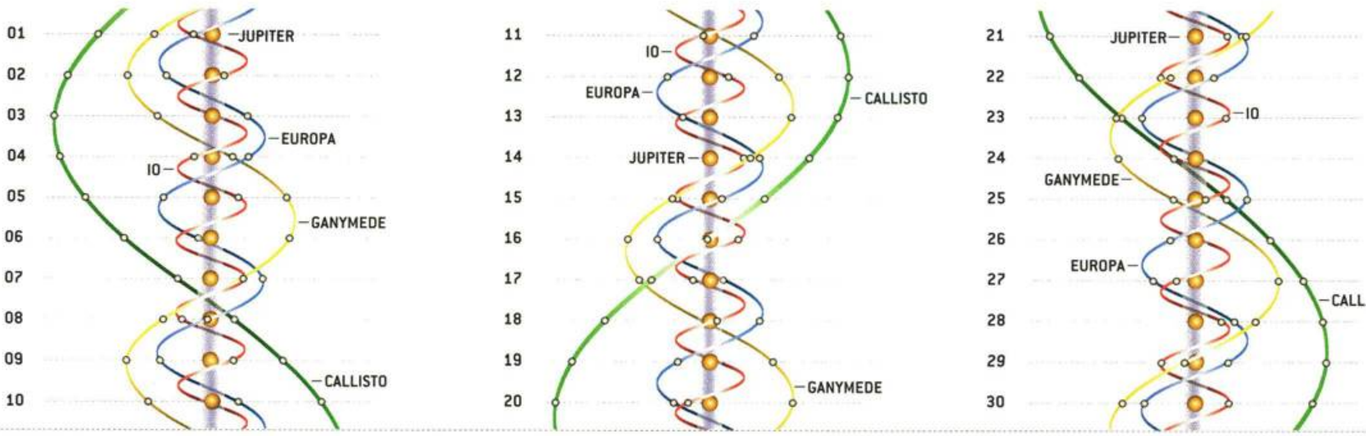
To locate the Moon in the sky, draw a line from the phase

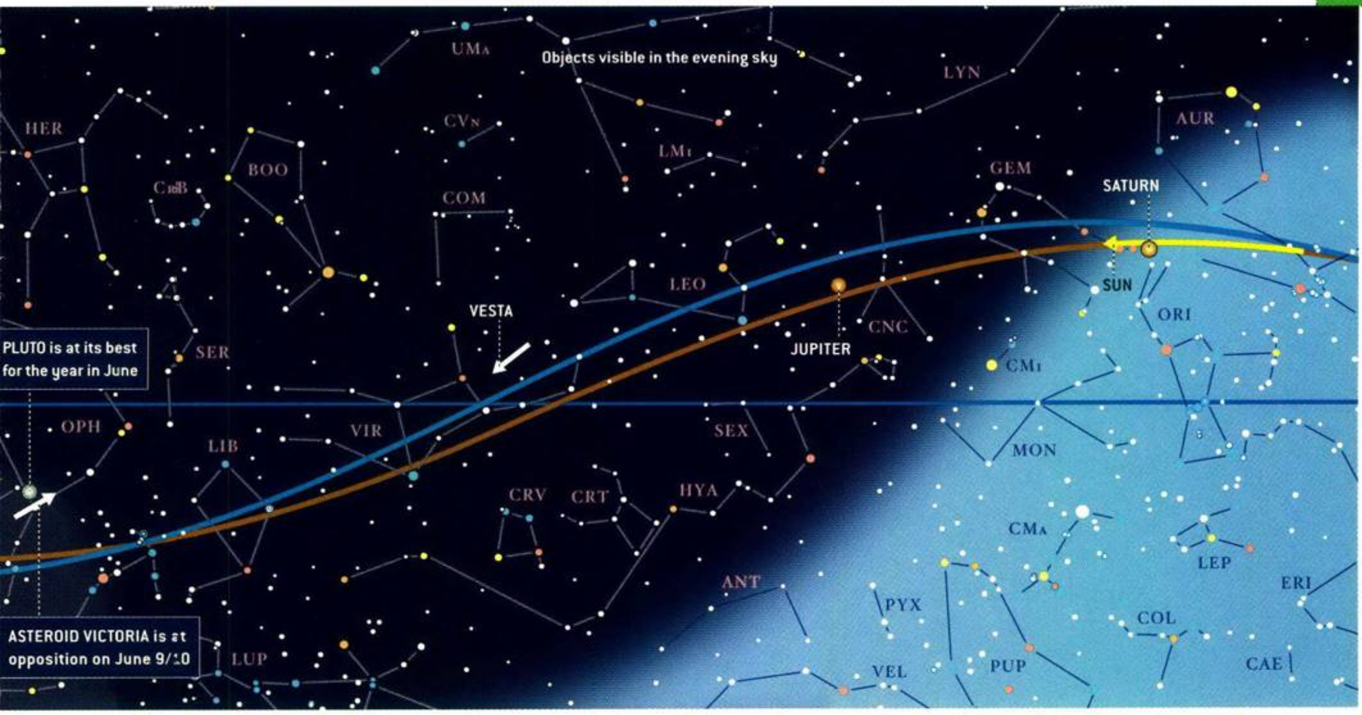
PLANETS 	 MERCURY	 MERCURY	 VENUS	 MARS	 MARS
Date	June 1	June 15	June 15	June 1	June 3
Magnitude	0.8	−0.3	−3.9	−0.7	−1.4
Angular Size	8.6"	6.4"	10.3"	12.4"	16.5"
Illumination	34%	63%	95%	87%	90%
Distance (AU) from Earth	0.780	1.044	1.623	0.754	0.567
Distance (AU) from Sun	0.441	0.371	0.723	1.435	1.407
Right Ascension (2000.0)	2h58.7m	4h05.1m	4h16.6m	21h42.9m	22h33.
Declination (2000.0)	13°08'	18°36'	20°25'	−16°36'	−13°41

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.

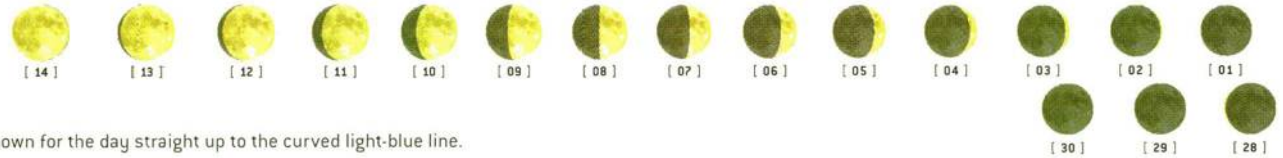


uares show motions and locations of solar system objects during the month.


Objects visible in the evening sky
UMA
HER
CVN
LYN
AUR
BOO
LMI
CRB
COM
GEM
SATURN
SUN
LEO
ORI
VESTA
CNC
JUPITER
SER
CMI
OPH
SEX
VIR
LIB
MON
CRV
CRT
HYA
CMA
LEP
ANT
ERI
PYX
COL
LUP
VEL
PUP
CAE

PLUTO is at its best for the year in June

ASTEROID VICTORIA is at opposition on June 9/10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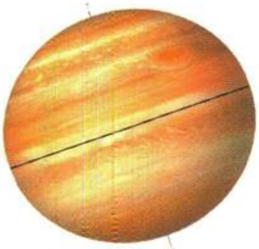
hown for the day straight up to the curved light-blue line.

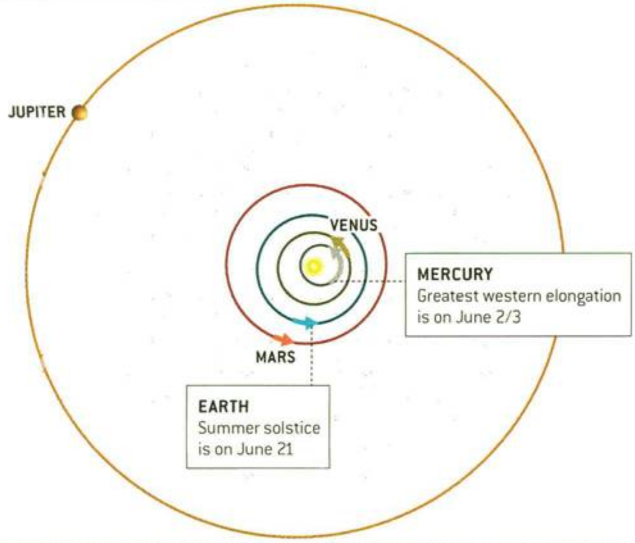


	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
0	June 15	June 1	June 15	June 15	June 15
	−1.9	0.1	5.8	7.9	13.8
	33.3"	16.7"	3.6"	2.3"	0.1"
	99%	100%	100%	100%	100%
	5.926	9.981	19.644	29.410	29.661
	5.353	9.031	20.026	30.080	30.659
2m	9h10.8m	5h58.2m	22h20.0m	21h01.5m	17h13.0m
'	17°06'	22°36'	−11°12'	−16°56'	−13°27'

STO

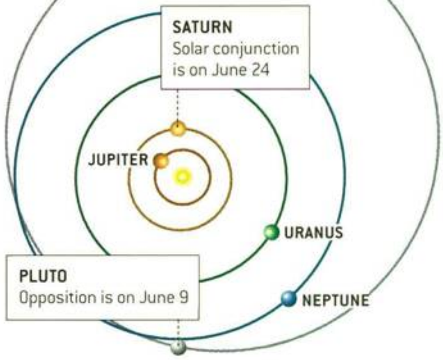
The planets in their orbits

Arrows and dots show planets' positions during the month.


JUPITER
VENUS
MARS

MERCURY
Greatest western elongation is on June 2/3

EARTH
Summer solstice is on June 21


JUPITER
URANUS
NEPTUNE

SATURN
Solar conjunction is on June 24

PLUTO
Opposition is on June 9

THE DEEP SKY

The Northern Crown doesn't offer much in the way of galaxies or nebulae, but it glitters with a number of stellar jewels.

THE BOX NEBULA (NGC 6309) in Ophiuchus lies just a short hop north of Pluto this month. CALTECH/POSS

The crown of the northern sky

The regal title of Corona Borealis is bestowed upon a charming tiara of stars that any monarch would be proud to wear on his or her head. Its jewels consist of nearby stars, pairs, and interesting variables. "Cor Bor," as amateurs affectionately call it, ranks among the smaller constellations, and by bad luck does not contain any bright clusters or galaxies. The flip side of this astronomical coin is that you can readily survey much of the Northern Crown in one night.

The semicircular pattern of Corona Borealis catches the eye under a dark sky, but you'll probably need binoculars to trace its form through the veil of light pollution. Just inside the crown on the east side lies the magnificent "reverse" variable star R CrB. It sits at 6th magnitude — visible to the naked eye — for months or even years at a time, then belches out a huge amount of dark carbon soot that causes it to plummet eight magnitudes in the matter of a week.

Astronomers simply don't know if R's next plunge will begin tonight or next year. Full Moon or not, it will take you less than five minutes every night to check its vitals, with a pair of binoculars and a free chart from the website of the American Association of Variable Star Observers at www.aavso.org. Make sure you keep records, because every observation can be valuable.

If you've let your scope cool down, visit some of the double stars inhabiting Corona Borealis. Use the chart at right to hop over to the wide pair Nu^1 (ν^1) and Nu^2 (ν^2) CrB. Although ESA's Hipparcos satellite measured their distances to be similar, about 550 light-years, they're heading in different directions, so they appear to be unrelated.

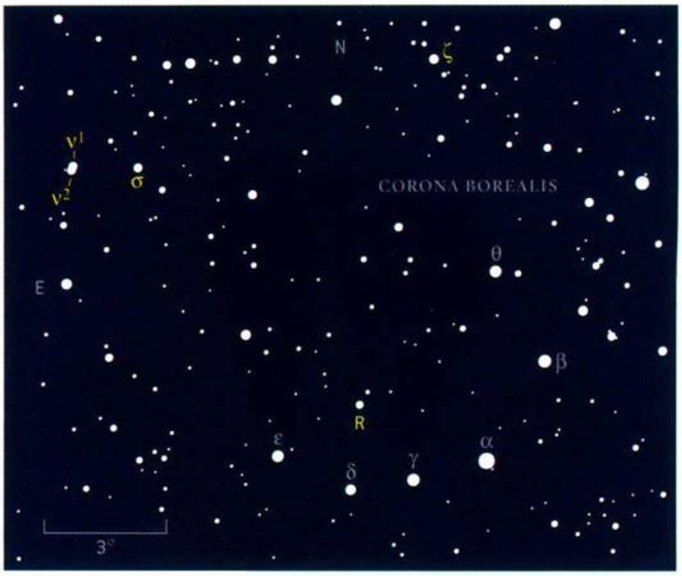
Next slide westward to Sigma (σ) CrB. A lovely pair for a small telescope, these two stars shine at magnitude 5.6 and 6.6 and have a comfortable separation of 7.2″. You probably won't split them at low power, so bump up the magnification to 100x. It will be a few centuries before humans witness a complete orbit, since it takes about a thousand years.

An 8° hop to the west-northwest will land you on a similarly attractive pair, Zeta (ζ) CrB. These stars shine brighter, at magnitude 5.1 and 6.0, and 6″ separate the pair. In both cases, the stars appear fairly colorless. You can have fun by first staring into a bright red flashlight to see if they turn greenish-blue.

A planetary in Pluto's proximity

The great visual observer Sir William Herschel coined the name "planetary nebulae" to describe the tiny puffballs of gas that looked like pale versions of Uranus or Jupiter. In fact, they represent the dying coughs of a star's final years.

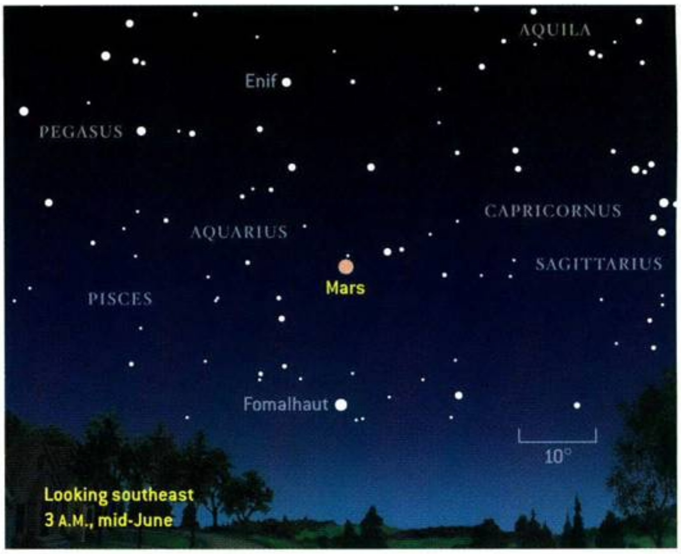
On your way to Pluto, stop by the planetary NGC 6309. At magnitude 11.5, it's considerably easier to find than poor Pluto. Its nickname, the "Box Nebula," arose because it appears to have subtle, squarish edges at high power. The central star shines noticeably at 13th magnitude in 8-inch or larger scopes. If you have a nebula or light pollution filter, try moving it back and forth between your eye and the eyepiece. The Box will appear to turn on and off like a distant lighthouse beacon.



Martin Ratcliffe is former President of the International Planetarium Society. ***Alister Ling*** *is a meteorologist with Environment Canada.*

THE PLANETS

As brightening Mars finally pushes its way into the evening sky, Jupiter continues to hold sway after sunset.



Five bright planets can be seen during these warm June nights. This will be your last chance to spot Saturn, which sets soon after the Sun. Jupiter, however, hangs in the dusk until late evening. Mars, now a spectacular object, dominates the middle of the night as it moves into Aquarius. By dawn, the two inner planets, Mercury and Venus, put on a nice final act before sunlight hides the stars from view.

Take a quick view of **Saturn** as it sinks in the twilight glow of early June evenings. A slim crescent Moon hanging just above Saturn makes spotting the Ringed Planet much easier on June 1. Between then and the 5th, the growing crescent crosses the gap between Saturn and Jupiter. This attractive evening scene should also provide a wonderful photo opportunity. Set your camera on a tripod and use 200- to 400-speed film. With the aperture set one stop below its widest setting, take a series of exposures from 5 to 30 seconds to try to capture the rapidly changing evening light. Including foreground trees in silhouette will add to the beauty of your image. Saturn ducks behind the Sun in late June, reaching solar conjunction on the 24th.

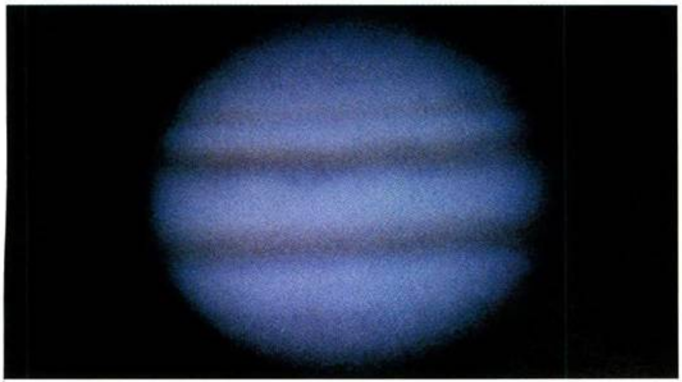
While Saturn disappears quickly, **Jupiter** remains a fine evening performer. Shining at magnitude –1.9, Jupiter will be easy to spot in twilight. And that's a good time to view it through a telescope because the reduced contrast with the background sky makes the subtle atmospheric features stand out more clearly. Jupiter sets around midnight in early June and by twilight's close on the 30th.

The series of mutual satellite events involving Jupiter's four major moons continues unabated this month. It will be your last good chance to view these events for the next six years. Of the 50 or so events during June, only about a third can be seen from North America, and most of those from only part of the continent. See "Shadow Play around Jupiter," December 2002, for observing details, and Astronomy.com for a full list of predictions.

The two best events this month involve Ganymede. The solar system's largest moon eclipses Io on June 7 at 11:55 P.M. EDT (8:55 P.M. PDT), an event best seen in western North America. A week later, Ganymede eclipses Europa. For seven minutes starting at 10:55 P.M. EDT (7:55 P.M. PDT), Europa will nearly disappear for viewers in the eastern half of the continent.

For observers with access to a dark-sky site, June is the best month to track down **Pluto**. The solar system's most distant planet lies opposite the Sun on June 9. However, the Moon will brighten the night sky during the middle two weeks of June, so your best bet is to try either during the first or last week of the month.

Pluto glows dimly at magnitude 13.8 among the rich star fields of southern Ophiuchus. Consequently, a well-adjusted 8-inch telescope at a dark site and a good star map as a guide should be all you need to spot it. (See "Find the faintest planet" on page 76 for observing tips and a detailed finder chart.) No doubt about it, seeing Pluto in the eyepiece will be a challenge. If you can attach a CCD camera to your scope, take images of Pluto's field on consecutive nights — you should have little problem picking out the planet because its motion will betray its identity. Pluto lies 2.5° north of 2nd-magnitude Eta (η)



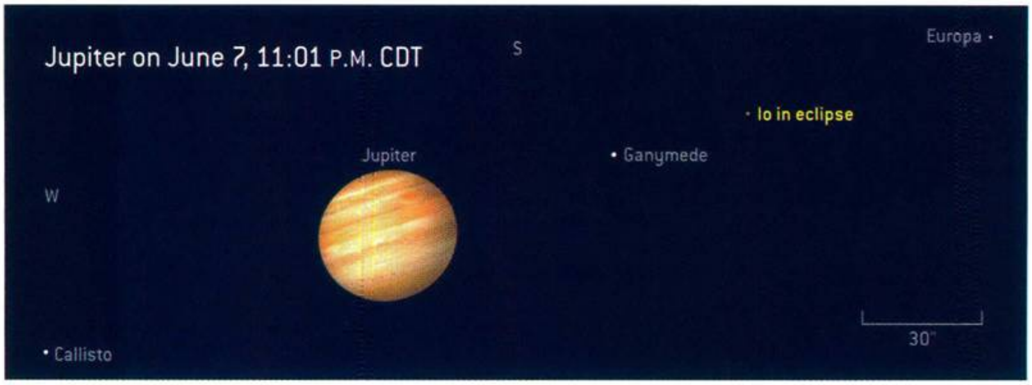
JUPITER'S BANDED ATMOSPHERE remains a fine target in June, but it's the last month for good views during this apparition. JEAN DRAGESCO

Ophiuchi and 2° west of 4th-magnitude Nu (ν) Serpentis.

Neptune, the eighth planet from the Sun, rises shortly after midnight on June 1 and two hours earlier by month's end. You'll have an easier time finding it than during the past few years because it lies just 1° west-northwest of the 4th-magnitude star Theta (θ) Capricorni. Neptune glows at magnitude 7.9 and reveals a 2.3"-diameter disk when seen in a telescope. That's too small to see any detail, although its blue-gray hue should come through.

Distant, dim Neptune can't hold a candle to nearby, bright **Mars**. During the next five months, we'll be up-close and personal with the Red Planet like never before. When Mars reaches opposition on August 28, it will span 25.11" and shine at magnitude –2.9 — bigger and brighter than at any time in the past 50,000 years. Yet previous oppositions have brought Mars almost as close to Earth. The planet's best recent appearance occurred in August 1971, when it spanned 24.91". And in 1924, it reached 25.10" in apparent diameter.

Mars really starts to impress this month. It nearly doubles in brightness, going from magnitude –0.7 on the 1st to magnitude –1.4 on the 30th. And its apparent diameter grows by one-third, from 12.4" to 16.5". Mars also rises earlier each night, coming up before midnight by the end of June. It currently lies in a star-poor region of sky, crossing from eastern Capricornus into Aquarius on June 9.

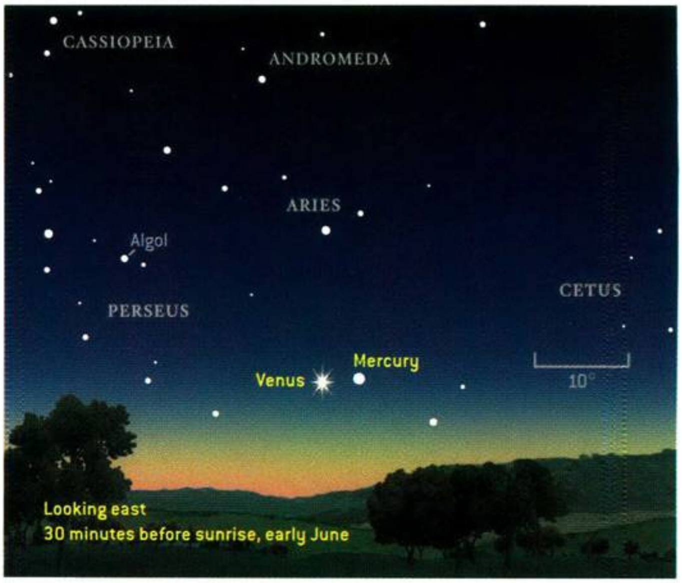

Jupiter on June 7, 11:01 P.M. CDT

So what's there to see on Mars? Well, after all the hype, reality sets in when you first view Mars. Put it anyway you like, Mars is tiny. (Even at its best in August, it will still appear smaller than Jupiter or Saturn's rings ever get.) Yet experienced observers can still see plenty. That's why you need to get some practice in viewing now. The chances of seeing detail increase with experience and the steadiness of Earth's atmosphere. Your first view will likely show a shimmering orange ball with little detail beyond the bright polar caps. Give your eye a few minutes to adjust to the bright object, and study carefully. Slowly you'll begin to spot features during moments of steady seeing. These precious moments of stillness are what expert observers capitalize on and casual observers often miss.

On June 19, the Moon, Mars, and Uranus lie within a 5° circle. The waning gibbous Moon stands 2° south of Mars, a stunning pair in the after-midnight hours. **Uranus**, barely visible to the naked eye on most nights but easily detected in binoculars or a small telescope, lies nearby. This gas-giant planet glows at magnitude 5.8 and lies 3.5° north of Mars that same night.

Venus and **Mercury** appear by the break of dawn, albeit briefly before being drowned by the brightening sky. Venus rises an hour before the Sun on June 1. It should be easy to spot, blazing brightly at magnitude –3.9. Seeing Mercury, on the other hand, may require binoculars. Mercury shines at magnitude 0.7 and lies 4° to the right of Venus. The inner planets change their relative positions little during the first two weeks of June, but Mercury brightens to magnitude –0.3 by the 15th, making it easier to see.

After June 15, the two approach each other rapidly. Mercury's motion carries it beneath Venus, passing just one Moon-width south of its companion on June 21. Mercury will have brightened another half-magnitude by this time, making them an attractive pair in binoculars. The view through a telescope will show Mercury's gibbous phase (three-quarters lit) and an almost full Venus, with Venus roughly twice the size. Both planets get lost in the Sun's glow soon thereafter.



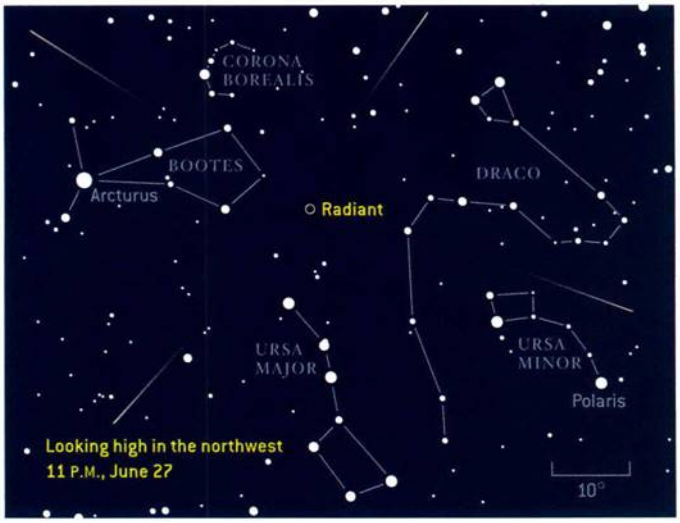
Looking east
30 minutes before sunrise, early June

METEORS AND MOONS

An unpredictable meteor shower may grace the late June sky, while a young and flashy pair of lunar craters vies for attention as the Moon waxes.

June Boötids

Active from June 26 until July 2, the June Boötid meteor shower remains an enigma. The shower produced nice displays in 1916, 1921, and 1927, and then — nothing. Or at least rates dropped to only one or two meteors per hour. But the shower returned with a vengeance in 1998, when the zenithal hourly rate (ZHR) shot up to 50 to 100 meteors per hour for more than half a day. (The ZHR measures how many meteors would be seen if the shower's radiant was overhead in a pitch-black sky. An observer invariably sees rates lower than the ZHR.)



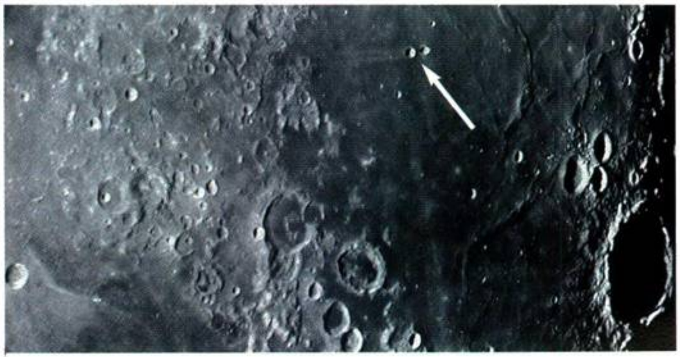
Looking high in the northwest
11 P.M., June 27

These meteors apparently originated as debris from Comet 7P/Pons-Winnecke. The good displays in the early 1900s coincided with the comet's perihelion passage, but not the one in 1998. And the past four years haven't produced a trickle.

This year a nearly New Moon, combined with the all-night visibility of the radiant in northern Boötes, creates ideal conditions to watch for another outburst. Few meteors may appear, but a repeat of 1998 could add greatly to our knowledge of this poorly understood shower.

Moon feature: Messier

Messier and its companion, Messier A, form an interesting pair of craters in Mare Fecunditatis. Under full Sun, Messier A has a pair of bright rays that extend west across the lava plains. Appearing rather like a comet's tail, the rays can sometimes be seen under low angles of illumination. The Sun rises over this region on the fourth day after New Moon, so start looking for it on the evening of June 3.



THE PAIR OF YOUTHFUL CRATERS known as Messier and Messier A shows striking rays visible shortly after sunrise. FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)

Messier lies to the east of Messier A, closer to the sunlit limb. It appears distinctly elongated, measuring 5 by 7 miles, and its long axis aligns with the slightly larger and more circular Messier A. The impacting object likely came in at a shallow angle, perhaps bouncing like a stone skipping on water or splitting in two just before impact. Whatever their history, the craters are only a few hundred million years old. This age estimate comes from the brilliance of the crater walls, the presence of the rays, and the lack of many overlying craters. Over significant periods of time, solar radiation dulls craters and ray systems. Craters with ray systems, such as Messier, Tycho, and Copernicus, rank among the youngest features on the Moon.

Jupiter's satellites

The rare occultations, eclipses, and transits of the outer Galilean moon, Callisto, continue. Events listed above are given in both Universal Time and Eastern Daylight Time. Those that occur near midnight are shown twice because the date changes for observers in Europe or North America. Oc = occultation; Ec = eclipse; Tr = transit; Sh = shadow transit; D = disappearance; R= reappearance; I = ingress; E = egress.

/// JUNE CALLISTO EVENTS

	{ UT }	{ EDT }	{ Event }
8	14:53	10:53	IV.Oc.D.
	19:48	15:48	IV.Oc.R.
		21:12	IV.Ec.D.*
9	1:12		IV.Ec.D.*
	6:01	2:01	IV.Ec.R.
16		22:02	IV.Tr.I.*
17	2:02		IV.Tr.I.*
	6:51	2:51	IV.Tr.E.
	11:15	7:15	IV.Sh.I.
	15:57	11:57	IV.Sh.E.
25	10:45	6:45	IV.Oc.D.
	15:39	11:39	IV.Oc.R.
	19:16	15:16	IV.Ec.D.
		20:02	IV.Ec.R.*
26	0:02		IV.Ec.R.*

*Events that occur on either side of midnight are shown twice.

COMETS AND ASTEROIDS

A reasonably bright periodic comet arrives for a cup of tea, although Vesta remains the brightest piece of solar system debris.

Gunning for a comet

Feast or famine — that's what comet observing is all about. Next spring brings a good chance of seeing two comets with the naked eye. Unfortunately, the best we can expect this month is a single, 12th-magnitude fuzzball.

To snatch a view of Comet 65P/Gunn, wait for the dark moonless skies that come both at the start and end of June. Wait until 1 or 2 A.M. for Sagittarius to rise above the horizon murk and zero in on the base of the teapot shape. You'll probably need an 8-inch scope to find the faint roundish glow. Bump the power past 100x to darken the background sky and enlarge the comet's apparent size.

While you're in the area, stop by the large and bright globular star clusters M54 and M70. On the night of July 1/2, Comet Gunn grazes the northern edge of M70, which will make for a nice photo opportunity.

James E. Gunn discovered this comet in 1970 on a photographic plate taken with the 48-inch Schmidt camera on Palomar Mountain. It was brighter than usual because in 1965 it had passed close to massive Jupiter, whose enormous gravity changed the comet's orbit, bringing it closer to the Sun. Its closest point, or perihelion, changed by nearly one astronomical unit, the average distance between the Sun and Earth.

/// JUNE COMET POSITIONS

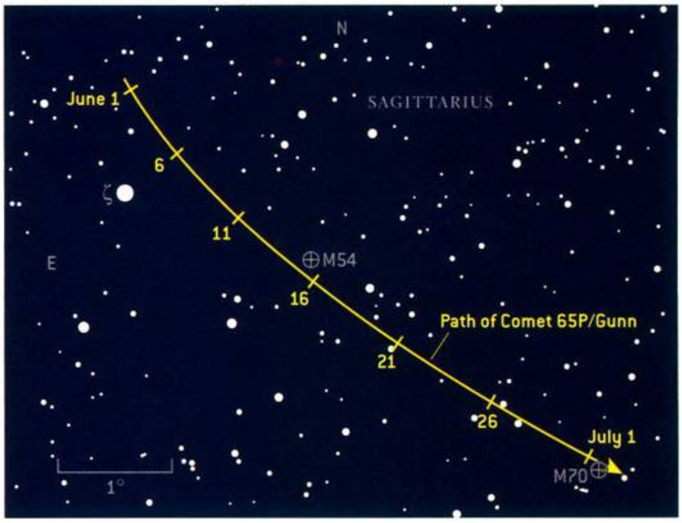
COMET 65P/GUNN

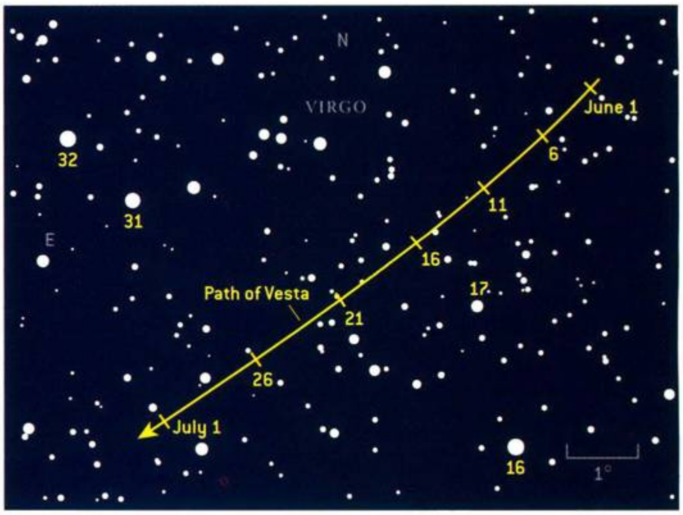
{Date}	{R.A.}	{Dec.}
June 1	19h02.3m	–28°59'
June 6	19h00.5m	–29°33'
June 11	18h58.0m	–30°07'
June 16	18h55.0m	–30°40'
June 21	18h51.5m	–31°13'
June 26	18h47.7m	–31°43'
July 1	18h43.7m	–32°11'

Vesta cruises on

If you've been following the large minor planet 4 Vesta for the past few months, it should be a snap to keep tracking it with binoculars, even from a city backyard. Glowing at 7th magnitude, this rocky denizen of the asteroid belt will be easy to pick out in the evening sky. It lies just a short hop west of the 3rd-magnitude stars Epsilon (ε) and Delta (δ) Virginis, both labeled on the circular star map at the center of this issue.

Few stars of similar brightness lie in the area, so you should be able to spot Vesta on the first try using the close-up map at right. If you're not sure which point of light marks Vesta, follow the tried-and-true method of asteroid sleuthing. Make a quick sketch of the stars you see, then return to the same field on the next clear night to see which one moved.





Every 17 months or so on average, Vesta makes a close approach to Earth. But some of these encounters offer better observing prospects than others because the asteroid's elliptical orbit brings it closer. The 2003 approach was fairly average, but the one coming in May 2007 will be exceptionally close. That year Vesta will peak at magnitude 5.4, making it an easy target for naked-eye observers under a dark sky. ■

/// JUNE ASTEROID POSITIONS

ASTEROID 4 VESTA

{Date}	{R.A.}	{Dec.}
June 1	12h16.1m	8°23'
June 6	12h18.8m	7°42'
June 11	12h22.1m	6°59'
June 16	12h25.9m	6°13'
June 21	12h30.2m	5°24'
June 26	12h35.0m	4°33'
July 1	12h40.2m	3°40'

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ASK ASTRO

Ursa Major moving group, calendar tidbits, cometary grain motion

URSA MAJOR MOVING GROUP

I read somewhere that the solar system is in the middle of an open star cluster that includes Sirius and the Big Dipper. Am I remembering this correctly?

— JON ZANDER, BOULDER CITY, NEVADA

THE SEVEN BRIGHTEST STARS in the constellation Ursa Major are commonly referred to as the Big Dipper, best visible during spring and summer in the Northern Hemisphere. DOUG RICHTER

Yes, your memory is largely correct. Most, but not all, of the stars in the Big Dipper are part of what astronomers call a "moving group" that surrounds the Sun. Moving groups are collections of stars that seem to share the same motion through space. A moving group is like an open star cluster, but looser and more sparsely populated. (The Dipper stars that don't belong to the group are Benetnasch, at the end of the handle, and Dubhe, at the outer lip of the bowl.)

Astronomers identify moving groups by finding stars that have similar proper motion. (Proper motion is a small but measurable change in celestial position over time.) But in any random sample of stars, some that don't belong to the group will have similar motions despite being at different distances. So to fill out the picture, astronomers also use information about the stars' distances.

For the brighter couple dozen stars in the Ursa Major moving group, their distances are confidently known from Hipparcos spacecraft data. This mission measured the distances of some 20,000 of the brightest stars in the sky. The Dipper's stars are about 80 light-years away, while other stars belonging to the group lie both closer and farther from Earth. These include Sirius (8.6 light-years away), Alpha Coronae Borealis (75 light-years), Beta Eridani (89 light-years), and Zeta Leonis (260 light-years). The group has roughly 40 known members.

The Ursa Major moving group formed out of a cloud of dusty gas about 300 million years ago. The cloud was not dense enough for the stars to stay tightly bound to each other by gravity for long, unlike the case of an open cluster such as the Pleiades. So the member stars began to disperse almost as soon as they started to shine, thanks to tidal forces from the Milky Way Galaxy.

The Sun, however, is not a member of the group. Its age is 4.6 billion years, making it far older than this group, which is just passing around us at present.

— BRIAN SKIFF, LOWELL OBSERVATORY

CALENDAR TIDBITS

My textbook says that perihelion occurs on January 2 and aphelion on July 4. Why are those dates different from the dates of the solstices?

— CINDY BLASER, AKRON, OHIO

The dates differ because the solstices and the points in Earth's orbit when it lies closest to the Sun (perihelion) and farthest from it (aphelion) have physical origins that bear no relation to each other.

The solstices and equinoxes (and more generally, the seasons) result from the inclination of Earth's rotational axis to its orbit. This tilt may have been produced by the last major impact that our planet received in its formative period. And the tilt is maintained by the action of the Moon on Earth (see last month's Ask Astro). On the other hand, the dates of aphelion and perihelion come from the orientation of Earth's elliptical orbit in space. That results from both circumstance and perturbations by the gravity of the other planets.

These two processes have no direct physical connection, so the fact that aphelion and perihelion come about 10 days after the solstices is purely coincidental. Moreover, the dates in any given year can stray a bit from those you mention. This happens because the yearly calendar contains an integer number of days (365), but the time it takes Earth to make one orbit of the Sun runs about a quarter-day longer.

Our present-day calendar handles this by the well-known "fudge" of adding a day every four years to make a leap year. But because that extra quarter-day actually falls a bit short of full measure, the calendar doesn't just roll out the leap years relentlessly. Instead it skips them in century-years, except for those that are evenly divisible by 400, as 2000 was. This keeps the calendar almost perfectly in tune with the solar year — the error won't reach as much as a day until the 51st century has arrived. — **ROBERT BURNHAM,** CONTRIBUTING EDITOR

DUST GRAINS ARE RELEASED in all directions from the nuclei of comets as water vaporizes and other materials explosively melt away. Streams of this material are often encountered by Earth. MPAE

COMETARY GRAIN MOTION

When a comet such as Tempel-Tuttle releases dust grains from its nucleus as it passes close to the Sun, don't the grains still have roughly the same velocity as the comet? If so, then celestial mechanics should make them follow the comet away from the Sun, instead of remaining in orbit so close to the Sun that Earth gets a Leonid shower once a year. What's happening? — THOMAS MOLL, STOCKHOLM, SWEDEN

Grains released from a comet travel with a slightly different velocity, since they are accelerated away from the comet by the expanding gas (mostly water vapor) that escapes from the comet as its ices sublimate. The exact velocity and direction for the grains vary with the location of the active areas on the surface of the rotating comet nucleus, and at which point during the comet's rotational "day" the grains are released. So dust grains can both lag behind and draw ahead of the comet in its orbit.

Once released from the nucleus, the orbital motion of the grains is further affected by two different forces. The first force is radiation pressure from the Sun, which tends to push the grains out to larger orbits. The smallest grains form the smooth, yellow-white dust tails we see with many comets, but the larger grains simply lag farther behind the comet in its orbit.

The second force is known as the Poynting-Robinson force, and it is caused by the fact that the moving grains "see" sunlight apparently coming from slightly ahead of them. This is the same effect as the aberration of starlight. (A common terrestrial example is the way a person walking on a rainy day has to tilt an umbrella ahead because the rain drops seem to fly in his face thanks to his forward motion.) In the case of comet dust, the momentum of the solar photons impinges more on the forward moving side of the grains than on the trailing sides. This causes the grains to slowly spiral in toward the Sun. This effect is greatest for grains with radii between about a tenth of a millimeter and several centimeters.

Finally, as grains move away from the comet, they experience slightly different perturbations from the gravity of planets as they follow (or precede) the comet around its orbit.

The net effect of all these forces is that over many dozens of orbits, the older grains disperse completely around the comet's orbit, forming a continuous meteoroid stream. Still, the greatest number of grains, those more recently released, tend to concentrate near the comet in its orbit, which is why we see bright meteor storms each time Tempel-Tuttle comes back, every 33 years. — **PAUL WEISSMAN,** JET PROPULSION LABORATORY

ASTRONOMY: KELLIE JAEGER

Crux, Musca, and Circinus

Three of the sky's smallest constellations hold a large assortment of southern Milky Way delights. /// BY TOM POLAKIS

The most southerly stretch of the Milky Way is one of its most interesting. Looking 60° away from the galactic center, we find scores of nearby double stars, clusters, and nebulae crowded into a small area. In the deep south reside Crux, Musca, and Circinus, three of the sky's smallest constellations. While they occupy less than one percent of the celestial sphere, they are far from insignificant to deep-sky observers.

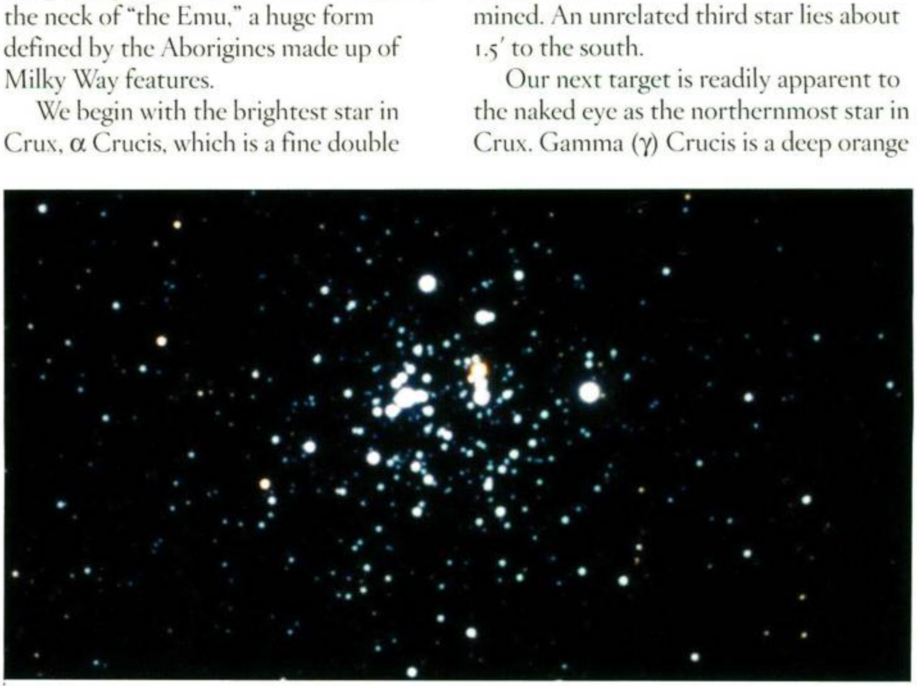
The smallest of the 88 constellations is, paradoxically, one of the most obvious. Crux, the Southern Cross, is so striking in southern skies that it has earned a position of distinction on the flags of Australia and New Zealand. The five stars of Crux are unassociated except for Beta (β) and Delta (δ) Crucis at the east and west ends of the cross, which are separated by only 30 light-years. Three of its stars are brighter than 2nd magnitude and grouped in an area just 6° across. As if all these bright stars in such a small area weren't enough, the Milky Way's most prominent dark nebula resides in Crux. The **Coalsack** is a stark, starless area 4° across. Only one 5th-magnitude star shines in an otherwise empty region.

To the south of Crux is Musca the Fly. Separated by just over 1°, Alpha (α) and β Muscae are also physically close. Lying 300 light-years from us, their true separation is only 7 light-years. From β Muscae, α would shine brighter than magnitude –5. The stars are nearly identical blue-white spectral type B2 gems.

Surrounded by so many spectacular stellar groupings, Circinus the Compasses seems buried in the Milky Way. Its brightest member is α Circini, a 3rd-magnitude star 55 light-years away. At the northern edge of Circinus, the fairly abrupt end of the Great Rift marks the neck of "the Emu," a huge form defined by the Aborigines made up of Milky Way features.

We begin with the brightest star in Crux, α Crucis, which is a fine double star. Just 4″ to the east-southeast of the 1st-magnitude primary star is a secondary that is only a half magnitude fainter. The two stars appear to be physically associated, but an orbit has not been determined. An unrelated third star lies about 1.5′ to the south.

Our next target is readily apparent to the naked eye as the northernmost star in Crux. Gamma (γ) Crucis is a deep orange



THE JEWEL BOX is a stunning open cluster on the east side of Crux. DANIEL GARDINER star of spectral type M4. It is listed as a double star, but its white 6th-magnitude companion to the north is nearly 2′ away; 7x35mm binoculars effortlessly split the pair.

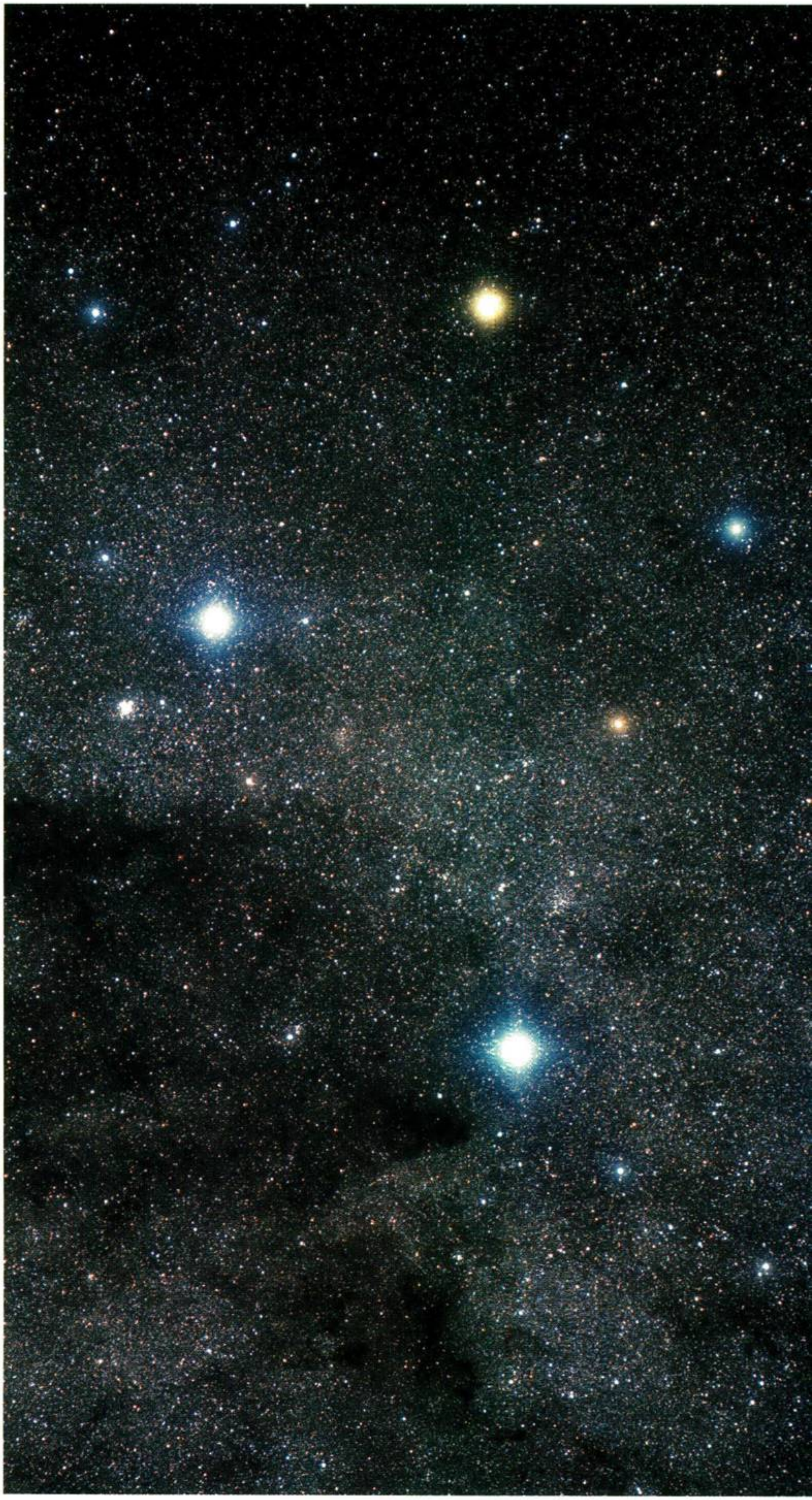
Crux is loaded with open clusters. Along the constellation's western edge lies **NGC 4103**, a tight grouping of 40 stars between magnitudes 10 and 13. There are no clumps of stars or central concentration in this cluster; it's just a uniform gathering. NGC 4103 stands out well from the very starry fields that permeate Crux. The distance to this cluster is 7,000 light-years.

Moving 2° south we come upon a wide pair of 4th-magnitude stars, Theta[1] (θ^1) and Theta[2] (θ^2) Crucis. The open cluster **NGC 4052** appears with them in a medium-power field. The modest assortment of 40 stars ranging from 11th to 13th magnitude resolves well in an 8-inch scope. The cluster creates a 7′-wide enhancement in star density that can just be made out from the surrounding Milky Way.

Pan a little more than a degree north of α Crucis to find the pretty open cluster **NGC 4349**. Seen from a distance of 5,700 light-years, this collection of stars shines as brightly as 5,000 suns. In a 12-inch scope, about 100 stars turn up in an area 12′ across. The cluster is defined by a number of tight clumps separated by dark voids. A yellow 7th-magnitude star lies just north of NGC 4349.

On the eastern edge of Crux, the Jewel Box Cluster, **NGC 4755**, is easily visible to the unaided eye. This well-defined clump of colorful stars contains at least 25 members brighter than 12th magnitude and shows up well in any telescope. A 10-inch scope shows 60 stars across an area about 10′ in diameter. Three bright stars — one yellowish, one blue, and the other orange — form a line across the center of the cluster. The orange star is Kappa (κ) Crucis, a type M supergiant that is primarily responsible for the cluster's colorful name. Other than the brightest stars in the Jewel Box, the majority of its members appear white to visual observers.

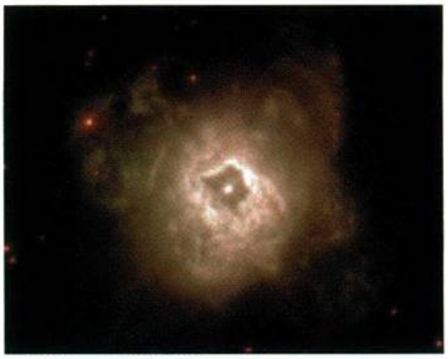
Just south of the Jewel Box is the Coalsack. At its southern edge sits the



CRUX is a prominent feature in the southern Milky Way. Part of the dark Coalsack Nebula appears at lower left. LUKE DODD

NGC 4833, a globular cluster, was first recorded by astronomer Nicolas Lacaille during his voyage to South Africa in the 1750s. DIGITIZED SKY SURVEY

NGC 5189 is sometimes called a "spiral planetary nebula" because of its odd resemblance to a spiral galaxy. DIGITIZED SKY SURVEY



NGC 5315 shows luminous color in this Hubble Space Telescope image of the planetary nebula. HOWARD BOND (STScI)/NASA

open cluster **NGC 4815**. Only the brightest members are resolved in an 8-inch telescope, through which the cluster resembles a small globular. Even in a 16-inch, only a few dozen stars are resolved, and two 9th-magnitude interlopers overwhelm the field. Due to the obscuring effect of the Coalsack, the stars are reddened, but this effect is not apparent in amateur instruments. Located about 8,000 light-years away, NCG 4815 is about the same age as the Hyades cluster in Taurus — about a half-billion years old.

Move to Lambda (λ) Muscae and pan 2° east-southeast to find the planetary nebula **NGC 4071**. At a distance of 4,000 light-years, it is a shell about one light-year across. Deep exposures show it as an ellipse containing a bar that crosses the nebula's minor axis and is flanked by bright ends. In a 13-inch telescope it appears like a ghostly, oval bubble almost an arcminute across with a diffuse edge. A 13th-magnitude star appears near the center, but this is not the planetary's true central star, which is 19th magnitude. An OIII filter enhances the view nicely, bringing out some internal structure when viewing with large apertures.

Less than a degree southwest of γ Muscae is **NGC 4372**, one of the least concentrated globular clusters in the sky. At a distance of 15,000 light-years, its brightest stars glow at 12th magnitude and are readily visible in modest instruments. An 8-inch shows NGC 4372 as a very loose collection of mainly 13th- and 14th-magnitude stars sprayed over an area 7′ across. There is almost no concentration toward the center; at 150x magnification it looks like a circular open cluster. In a 17-inch, the cluster is resolved to the core and becomes a magnificent collection of mostly equal-magnitude stars with no background glow. Just 5′ northwest of the core is an unrelated 7th-magnitude star.

The more typical globular cluster **NGC 4833** contrasts with NGC 4372. This is a moderately concentrated ball of stars that again resolves well in medium apertures. Dozens of 13th-magnitude members are visible in a 10-inch scope. Unlike NGC 4372, the broadly concentrated core displays an ambient haze of unresolved stars. This central region appears as an oval elongated east-west. NGC 4833 lies at a distance of 25,000 light-years.

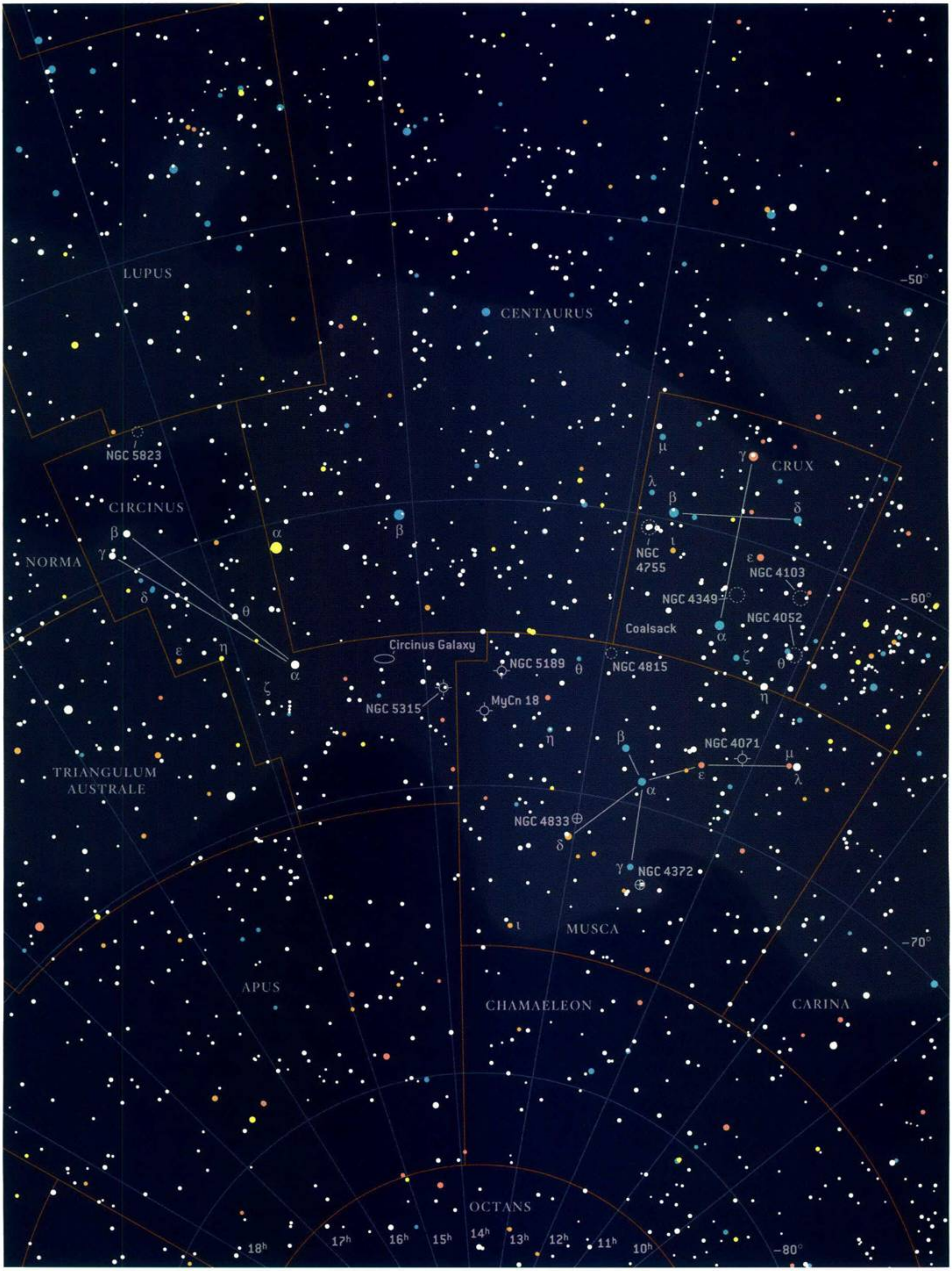
The prominent star β Muscae is a fine binary for telescopes with good optics.

/// Deep-Sky Objects in Crux, Musca, and Circinus

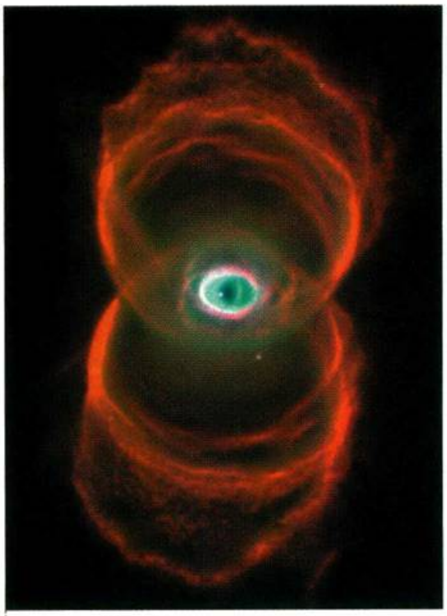
OBJECT	R. A.	DEC.	MAG.	SIZE/SEP.	TYPE	NOTES
Lambda Muscae	11h45.6m	–66°44′	3.6/12.1	41″	Dbl	—
NGC 4052	12h01.9m	–66°12′	8.8	7′	OC	—
NGC 4071	12h04.2m	–67°18′	13.0	75″	PN	—
NGC 4103	12h06.7m	–61°15′	7.4	6′	OC	—
NGC 4349	12h24.5m	–61°54′	7.4	15′	OC	—
NGC 4372	12h25.8m	–72°39′	7.3	18.6′	GC	—
Alpha Crucis	12h26.6m	–63°06′	1.4/1.9	4″	Dbl	Acrux
Gamma Crucis	12h31.2m	–57°07′	1.6/6.4	111″	Dbl	—
Beta Muscae	12h46.3m	–68°06′	3.7/4.0	1.3″	Dbl	—
Coalsack	12h53.0m	–63°18′	—	400′ by 300′	DN	—
NGC 4755	12h53.6m	–60°20′	4.2	10′	OC	Jewel Box Cluster
NGC 4815	12h58.0m	–64°57′	8.6	3.0′	OC	—
NGC 4833	12h59.6m	–70°53′	7.0	13.5′	GC	—
NGC 5189	13h33.5m	–65°59′	9.9	153′	PN	Spiral Planetary
MyCn 18	13h39.6m	–67°23′	12.9	25″	PN	Hourglass Nebula
NGC 5315	13h53.9m	–66°31′	9.8	5″	PN	—
Circinus Galaxy	14h13.2m	–65°20′	10.1	8.7′ by 2.8′	Gal	SA(s)b
NGC 5823	15h05.7m	–55°36′	7.9	10′	OC	—

Object: Designation in NGC or other catalog. **R. A. and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation is in arcseconds. **Notes:** Hubble types for galaxies.

Tom Polakis *is an aerospace engineer in Tempe, Arizona. He enjoys deep-sky observing and astrophotography.*


LUPUS
−50°
CENTAURUS
NGC 5823
CIRCINUS
μ
γ
CRUX
λ
β
δ
NORMA
β
γ
α
β
NGC 4755
ι
ε
NGC 4103
θ
δ
NGC 4349
−60°
NGC 4052
Coalsack
α
ε
η
α
ζ
θ
Circinus Galaxy
NGC 5189
θ
NGC 4815
ζ
η
NGC 5315
MyCn 18
η
β
NGC 4071
μ
TRIANGULUM AUSTRALE
ε
λ
α
NGC 4833
δ
γ
NGC 4372
ι
MUSCA
−70°
APUS
CHAMAELEON
CARINA
OCTANS
18h
17h
16h
15h
14h
13h
12h
11h
10h
−80°

THE CIRCINUS GALAXY is a huge nearby galaxy that lies among the rich starfields of the Milky Way. S. VAN DYK (IPAC) 2MASS/UMASS/IPAC-CALTECH/NASA/NSF



THE HOURGLASS NEBULA (MyCn18) is shown in full glory in this Hubble Telescope image. RAGHVENDRA SAHAI AND JOHN TRAUGER (JPL)/WFPC2 SCIENCE TEAM/NASA

NGC 5823 is an open cluster in Circinus that's split by a dark lane running through its center. DIGITIZED SKY SURVEY

The pair resembles headlights in the distance when viewed at magnifications above 150x. The secondary star is only slightly fainter and lies northeast of the primary. Some 300 light-years from Earth, the system's components complete a circuit every 383 years.

NGC 5189 is a planetary nebula that's in a morphological class of its own. While it is similar in some respects to the Eskimo Nebula in Gemini, it shows five sets of "ansae." This Latin term for "handles" describes small, symmetrically placed nodules opposing the central star. These rare features are thought to be short-lived. Seen from a distance of 5,000 light-years, the full extent of NGC 5189 is over 2′.

Some amateurs refer to NGC 5189 as the "barred spiral planetary" for its resemblance to that type of galaxy. A thin, bright bar about 2′ long traverses the planetary, which surrounds a 13th-magnitude central star. A 13-inch telescope reveals a "spiral arm" wrapping to the north from the west end of the bar and curling around a 12th-magnitude star. The southern arm is more diffuse and difficult to see. Much of the lacy detail in NGC 5189 is very sharply defined, a rare feature among planetary nebulae.

A considerably more difficult — but no less exotic — planetary nebula lies 1.5° to the south. In most telescopes, **MyCn18**, the Hourglass Nebula, appears merely as a 13th-magnitude star, perhaps showing a tiny, faint haze around the star. A very large telescope, however, begins to hint at the form that was revealed so spectacularly in Hubble Space Telescope images. Around the magnitude 14.5 central star appear two symmetrically placed rings, which are considerably fainter than the inner region. These structures are believed to be two hemispherical shells of gas ejected from opposite sides of the star.

Moving eastward into **Circinus**, we come upon another planetary nebula. **NGC 5315** is a tiny but bright nebula enhanced well by nebula filters. In a 12-inch scope it has a faint bluish color and begins to show a disk at magnifications above 200x. The central star is magnitude 14.2 and turns up at higher magnifications on nights when the air is stable.

While not a telescopically fascinating object, the **Circinus Galaxy** is well worth a look. This Seyfert galaxy wasn't discovered until 1977 as it is only 4° from the Milky Way's plane, where the light of distant galaxies is greatly dimmed. And despite being 12th magnitude, it lacks an NGC designation. Over 300,000 light-years across, the galaxy is enormous. Interestingly, it is also isolated. The Circinus Galaxy is not a member of the Local Group or any nearby galaxy group, nor does it have any known companions. Through a 13-inch telescope, it measures 4′ by 2′ and is moderately faint. Its core, which is 1′ in diameter, is much brighter. The intervening Milky Way provides a starry foreground for the galaxy.

Our final object is a pleasing open cluster in northern Circinus. Presenting 60 stars in an 8′ area, **NGC 5823** is well detached from nearby star-rich fields. To the south, a dark lane separates 12 stars from the main body of the cluster.

/// THE SOUTHERN CROSS

While now the Pole Star sinks from sight
The Southern Cross it climbs the sky;
But losing thee, my love, my light,
O bride but for one bridal night,
The loss no rising joys supply.
"Crossing the Tropics," Herman Melville (1819 — 1891)

Crux may be the smallest constellation in the heavens, but it is the most recognizable to southern observers. It lies between the legs of Centaurus the Centaur and once belonged to the larger constellation. Although earlier literary mentions of the Southern Cross exist, its first appearance in star maps came with the publication of Johann Bayer's *Uranometria* star atlas in 1603.

Sixteenth-century European sailors who ventured southward, such as Ferdinand Magellan and Amerigo Vespucci, found the cross-shaped foursome a useful navigational guide. Unlike Polaris in the north, there is no bright star near the south celestial pole. However, Crux's long axis points toward that important directional marker, and appreciative navigators recognized the tight stellar group as its own constellation.

After Augustus Caesar conquered Egypt, ancient Romans reportedly called the constellation Thronos Caesaris, the Throne of Caesar. At the time, Crux was not visible from Rome but could be seen from Alexandria. Due to Earth's precession, it is no longer visible in either city. — *Vanessa Thomas*

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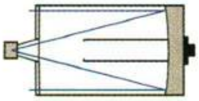

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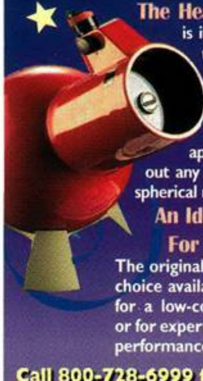

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PLANETARY OBSERVING

Early summer is the best time this year to hunt down the faint glow of the outermost planet. /// BY RICHARD TALCOTT

Find the faintest planet

Nearly every observer has a favorite solar system object. For some, it's the ethereal beauty of Saturn's rings. For others, the pockmarked lunar surface or the intricate surface markings of Mars rank at the top. Few observers would even think to include Pluto on this list, yet this mysterious world has a charm all its own.

Pluto's allure stems from its unique characteristics. Pluto is smaller and orbits farther from the Sun than any other planet. Those distinctions combine to make it the faintest planet as well — at magnitude 13.8, it appears nearly 1,000 times fainter than the naked-eye limit. Even Neptune, runner-up in the faintness competition, glows more than 100 times brighter than Pluto.

Although Pluto is certainly the most challenging planet to observe, it's not as difficult to see as you might believe. All you need is a good 8-inch telescope, a dark observing site, and the knowledge of when and where to look.

June and July make up the prime observing season this year. Pluto reaches opposition on June 9, when it lies opposite the Sun in our sky. That means the planet rises at sunset, appears highest in the south around local midnight, and sets at sunrise. In the weeks after opposition, Pluto moves into the evening sky and lies highest in the late evening.

Your best bet for finding Pluto is with an 8-inch or larger telescope. Although a handful of experienced observers have glimpsed the planet in a 6-inch telescope, the more aperture, the better. Compared with a 6-inch scope, an 8-incher gathers about 75 percent more light, a 10-inch glass collects more than two-and-a-half times as much light, and a 12-inch scope pulls in four times as much light. When you're searching for Pluto, every photon counts.

Next, choose an observing site as far from city lights as possible. Even a little bit of scattered light can drown out Pluto's dull gleam. Steady eyepiece views will help as well. Pick a site that looks out over a large expanse of grass, for example, and avoid asphalt parking lots, concrete buildings, and even the roofs of your neighbors' houses — anything that absorbs the Sun's heat during the day and releases it at night.

Just as light from a nearby town can hide Pluto from view, so can the natural illumination of the Moon. The best time to track down Pluto is on a clear night within five days or so of a New Moon. This summer, New Moons fall on May 31, June 29, and July 29.

When all the elements are in place, head to your observing site early to give

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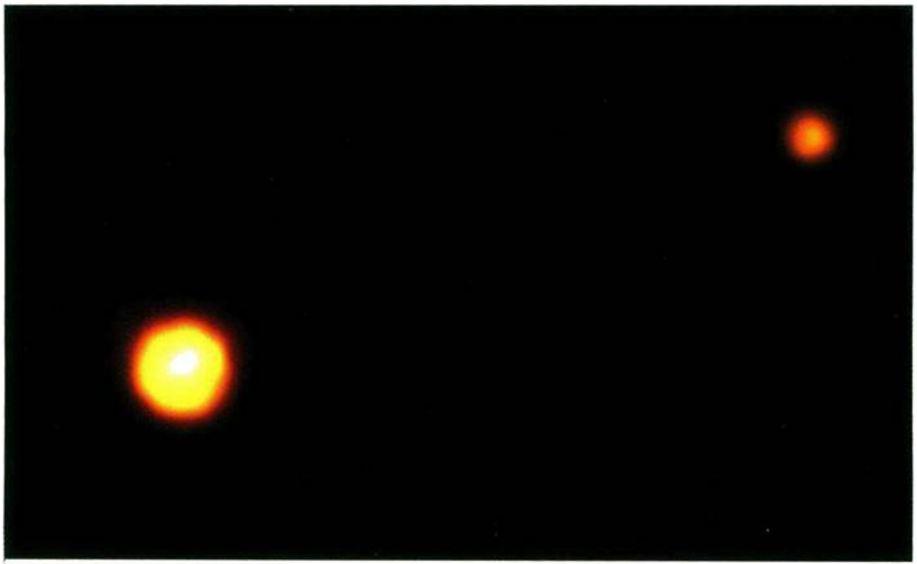
Richard Talcott *is senior editor of* Astronomy.



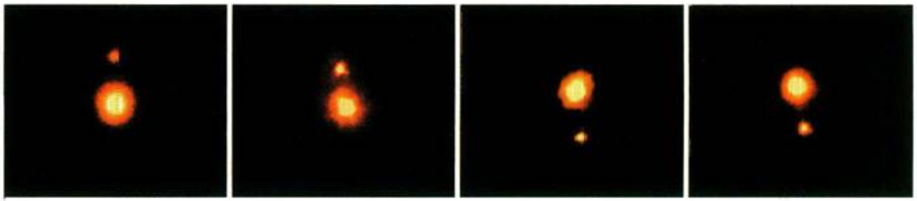
PLUTO AND CHARON posed for Hubble's Faint Object Camera in February 1994. R. ALBRECHT (ESA/ESO), NASA

/// POSITIONS OF PLUTO

Date	R. A.	Dec.
June 1	17h14m24s	–13°27'16"
June 11	17h13m19s	–13°26'49"
June 21	17h12m15s	–13°26'54"
July 1	17h11m13s	–13°27'34"
July 11	17h10m16s	–13°28'49"
July 21	17h09m27s	–13°30'39"
July 31	17h08m47s	–13°33'03"

R. A. and Dec.: Right ascension and declination in epoch 2000.0 coordinates. Positions are given for 11 P.M. Eastern Daylight Time.

SURFACE FEATURES are visible on Pluto in this 1994 Hubble image. NASA



PLUTO AND CHARON, the distant planet's even dimmer moon, are locked in a tight gravitational embrace, as evidenced by this series of infrared images taken in June 1999. GEMINI OBSERVATORY

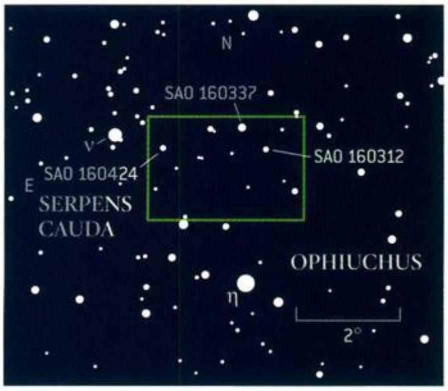
your eyes time to dark-adapt. Once the last vestiges of twilight have faded away, locate the 1st-magnitude star Antares, the ruddy heart of Scorpius the Scorpion. (Use the circular star map at the center of the magazine to find Antares.) From there, head 15° northeast to 2nd-magnitude Eta (η) Ophiuchi.

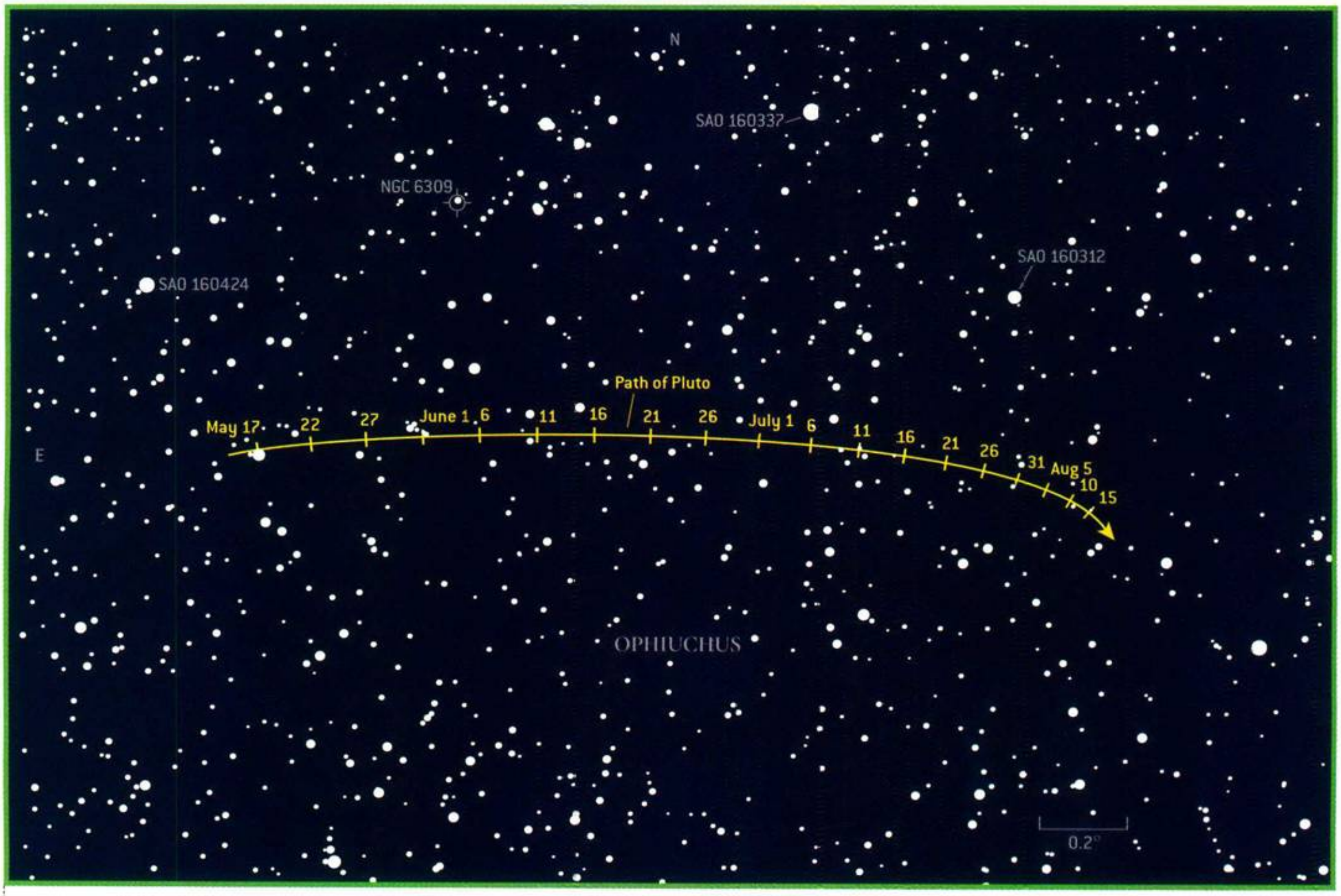
Now move 3° due north to SAO 160337. This 7th-magnitude star will serve as your guide to Pluto throughout the summer. With a low-power eyepiece, carefully starhop to the correct field using the detailed finder chart below. The chart shows north at top and east to the left. If your telescope inverts the view, typical with Newtonians, simply turn the map upside-down. Refractors and catadioptrics used with a star diagonal will flip the view left to right. Check out Astronomy.com for all three views.

Once you've centered Pluto's location, switch to high power. The chart shows stars down to magnitude 15.0, so you shouldn't have trouble identifying which point of light belongs to Pluto. If you're a bit unsure, however, make an accurate sketch of the field. Then observe the same field a night or two later. The "star" that has changed position is Pluto.

The faint glimmer of Pluto won't make you forget Mars or Saturn. You may not even return to Pluto until next year, or even years after that. But your success will put you in a select group of observers who have peered across 2.7 billion miles of space to gaze on the solar system's most distant world.

To learn more about Pluto and its path, visit http://www.astronomy.com/toc





DISTANT PLUTO may be easier to find with your scope than you think. Use the charts above to help locate its position in the sky. ASTRONOMY: ROEN KELLY

One of the finest solar photographers in the world shares his secrets to creating sensational portraits of the Sun. /// TEXT AND PHOTOGRAPHS BY JACK NEWTON

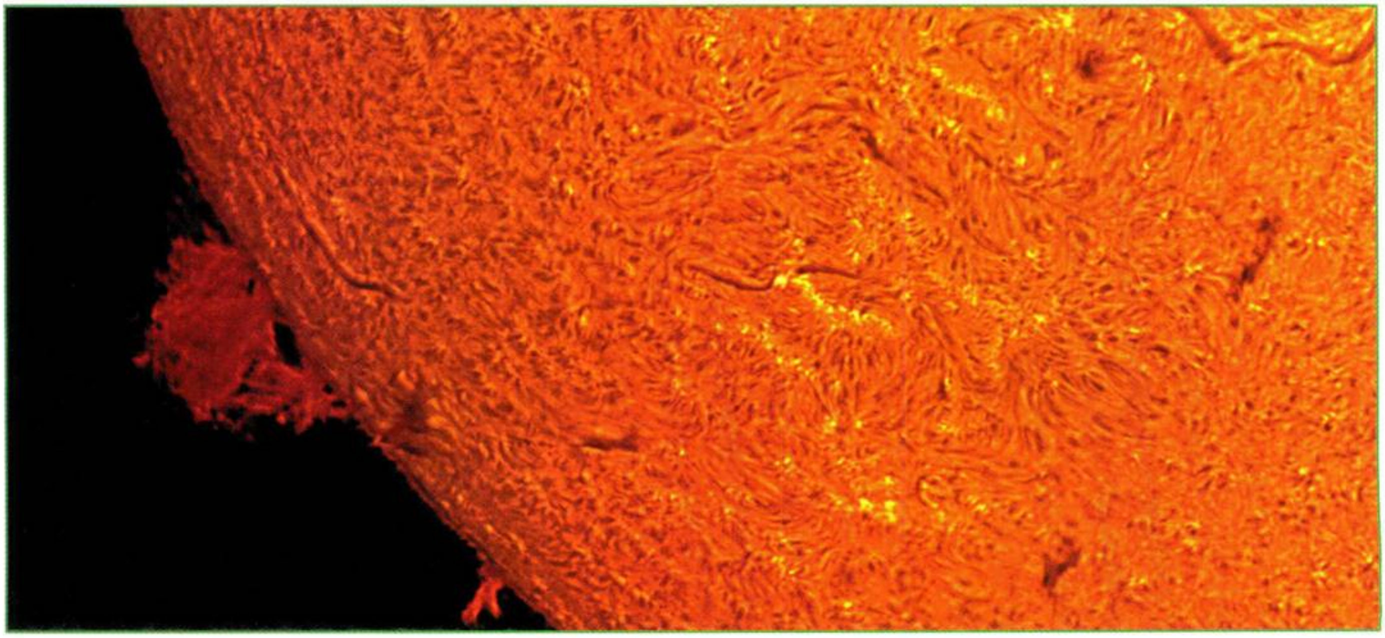
Imaging the Sun in Hα

June is a mean month for amateur observers. For those of us in the Northern Hemisphere, the shortest nights of the year fall on and around the summer solstice, cheating us of precious observing time. Or do they? It's true that the nights fly by, but then the days stretch out unhurriedly, making one star in the sky eminently visible.

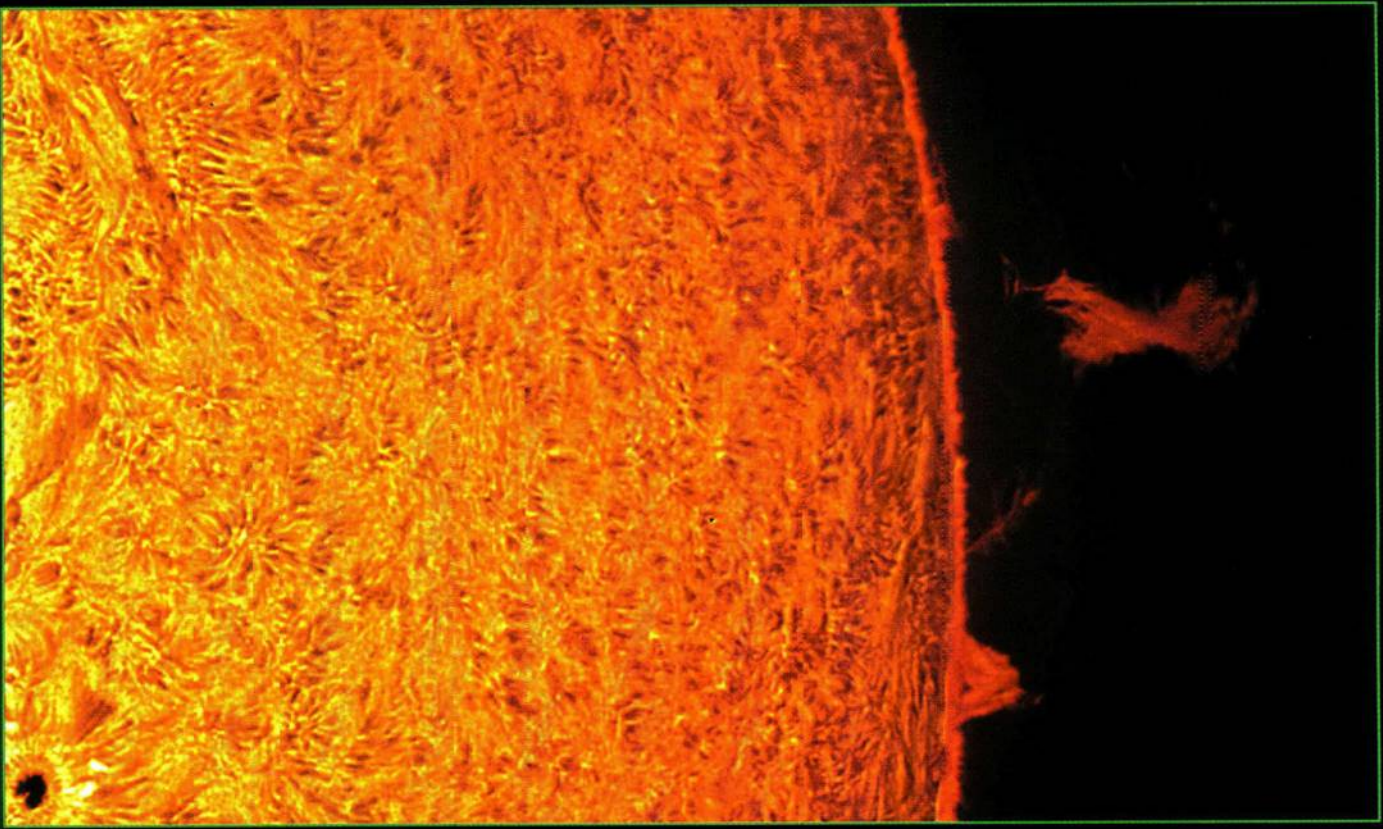
I've been fascinated by this star, the Sun, since I was a child, although back then I thought it shone unchangingly as it arced across the sky, day in and day out. But first impressions can be deceiving. When you see it under the right conditions, our host star is anything but staid: Fiery strands whip about its face, and dark splotches swirl across its surface. To see that kind of detail, you need a special solar filter that blocks out all wavelengths of light except one emitted by hydrogen called Hα (pronounced "H alpha"). It's an ideal window of light to let through because 92 percent of the Sun's atoms are hydrogen, and Hα is the wavelength that maximizes the details of the Sun's surface. While some solar filters simply cut down on the amount of light transmitted across all wavelengths (these are good tools, as well — the Sun should never be viewed directly), Hα filters give you unparalleled views of our nearest star in all its dynamic glory. They're also wonderful for solar imaging, one of my passions.

I first used an Hα filter in 2000, when fellow observer Gene Turner arranged for me to beta-test a 90mm model from Coronado Instruments. The fact that the filter fit immediately in front of the telescope's objective appealed to me. The first generation of solar filters went over the eyepiece so that sunlight was focused inside the optics, where it could do the most damage. Also, Hα filters require parallel light to function. At the eyepiece, where light is bent to a focus, such a filter would be useless unless coupled with a Barlow lens, which effectively stretches out the light path but also magnifies views. In older eyepiece filters, it was often impossible to see the Sun's whole disk at once.

The first views were stunning. Prominences, eruptions of gas kept in check by magnetic fields, appeared to leap off the limb. When seen against the disk, prominences look like dark wisps because they are cooler than their surroundings — a string of twenty Earths could lie along many of them. Bright regions next to dim sunspots, where intense magnetic fields

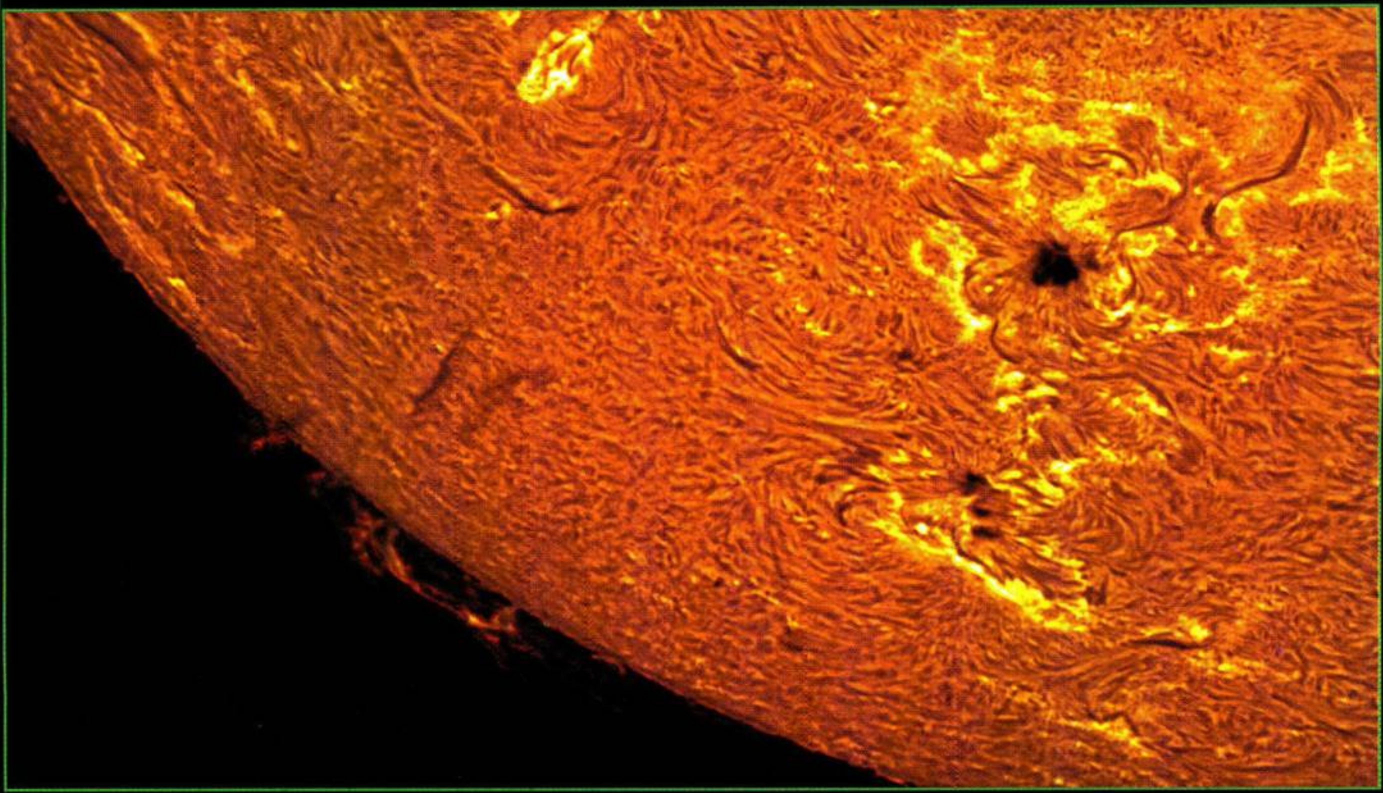


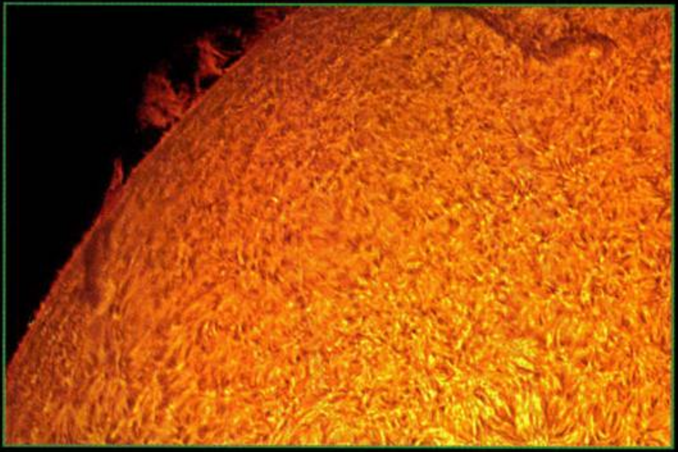
PROMINENCES leap off the limb of the Sun in this image taken September 12, 2002.



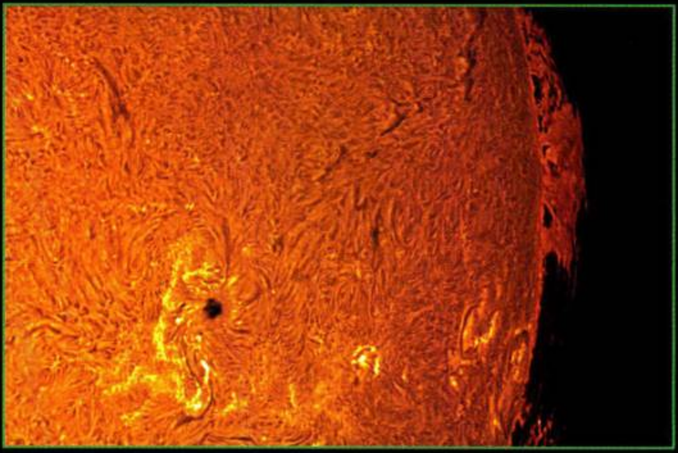
DETAILED SOLAR IMAGES require careful tweaking to bring out their subtleties. The disk and prominences were processed separately and then combined in this image taken on September 5, 2002.

Hα FILTERS allow only light of wavelength 656.3 nanometers to pass through, laying bare the dynamic action on the Sun. When the electron in a hydrogen atom drops from the second excited level to the first excited level, it releases a photon of Hα light. This photograph was taken September 10, 2002.





FILAMENTS, the sinuous dark regions in the upper part of this image from July 15, 2002, are simply prominences seen against the disk of the Sun.



TONGUES OF FIRE can reach heights of 400,000 miles in just an hour. This image was taken August 27, 2002.

are concentrated, can signal solar flares that drive hot solar plasma into the Sun's upper layers. Sometimes plasma is expelled so forcefully in coronal mass ejections that circuit breakers pop and communications are scrambled here on Earth.

I was anxious to capture the drama with my Meade Pictor 1616XTE CCD camera and 5-inch Meade apochromatic refractor. Coronado's 90mm SolarMax filter actually has two components — the Hα etalon filter that fits over the objective (a tip-tilt adapter ring attaches the filter to the scope) and a blocking filter (I used the BF 30) that receives a 2″ eyepiece. The blocking filter helps ensure only Hα light comes through and works to control image brightness.

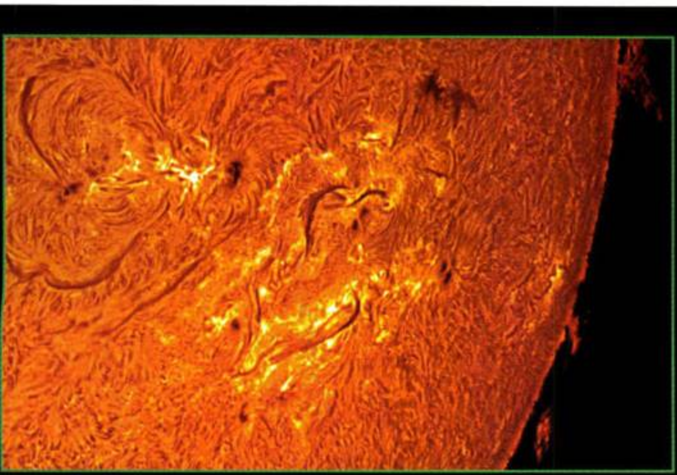
There are many ways to image the Sun, but here I'll outline my favorite techniques (see www.astronomy.com/toc for step-by-step instructions). I observe from a 16-foot diameter dome in the Arizona Sky Village, a new settlement for observers located 4,600 feet above sea level that was the brainchild of Gene Turner; my wife, Alice; and myself. A 16-inch Meade LX200 Schmidt-Cassegrain stands between two apochromatic refractors, a 5-inch and a 7-inch. A flip mirror on my CCD camera is parfocal to a CCD chip and attaches to both an observing eyepiece and a Nikon telextender that doubles the focal length to 90 inches at f/25. A dial gauge butted up to the CCD camera measures the position of the rack and pinion focuser, and a simple plastic drinking straw adjusts the length of the dial gauge's plunger for different cameras.

Unlike nighttime astrophotography, which requires long exposure times, good solar images can be snapped in a moment. A mere 0.04-second exposure at f/25 floods a 16-bit camera with about 35,000 levels of gray out of a maximum 65,000.

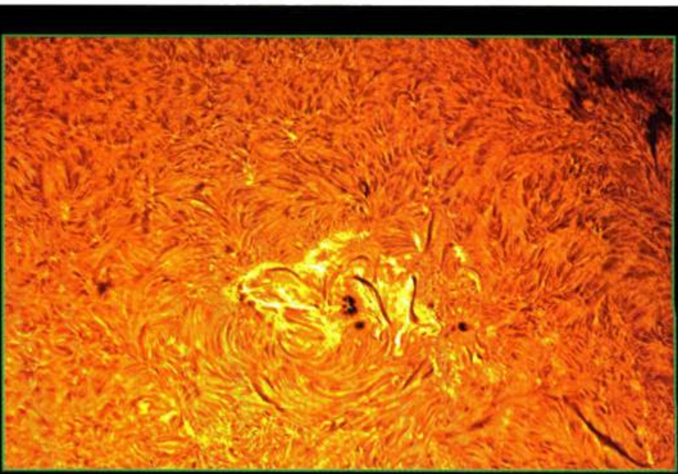
Once I take an image, I examine it for focus and contrast. You can adjust contrast easily by tipping the etalon filter using the adapter at its base, or by rotating the blocking filter's adjustable ring.

To tune the focus, use the rack and pinion and monitor the dial gauge. Some CCD images show rings that are caused by light interference generated by the glass cover over most CCD chips. Luckily, I don't see these so-called "Newton rings" because my Meade Pictor XTE CCD camera contains no glass over the chip.

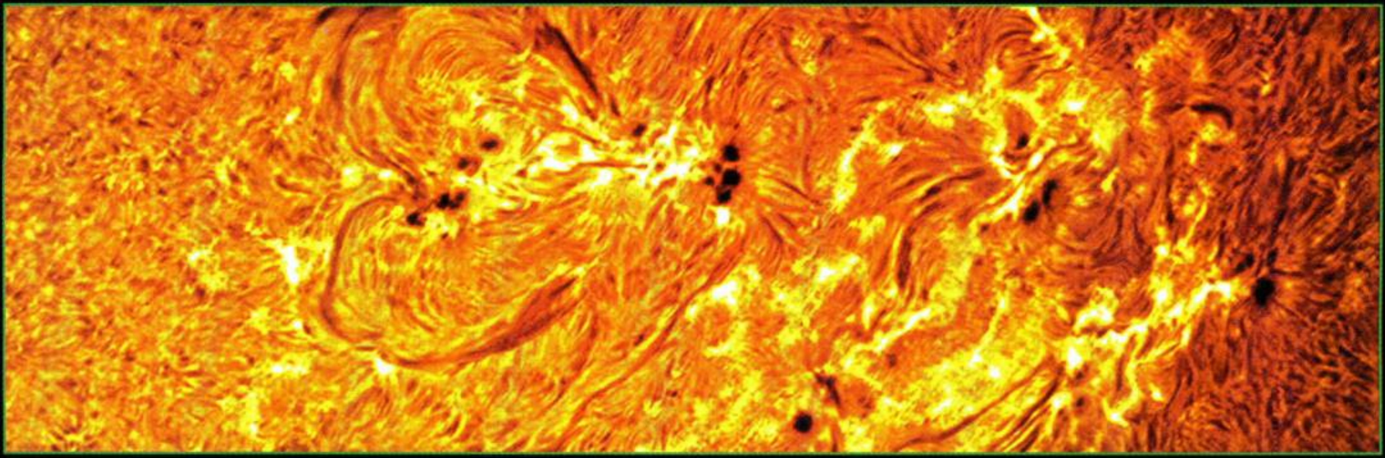
Jack Newton *runs an astronomy-focused bed and breakfast in Canada and a new housing community for amateurs in Portal, Arizona. Visit his website at www.jacknewton.com.*



BRIGHT REGIONS near sunspots can signal solar flares that may trigger coronal mass ejections, which are known to cause aurorae and disrupt communications on Earth. This image was taken July 31, 2002.



EXPOSURE TIMES for the Sun are extremely short — on the order of hundredths of a second. An image such as this, from July 15, 2002, can also be processed relatively quickly because it does not contain prominences.



SUNSPOTS, such as the ones imaged above on July 30, 2002, fluctuate in number over an 11-year cycle, whose high point is known as the solar maximum. The National Oceanic and Atmospheric Administration keeps tabs on solar activity and predicts that the downturn we are experiencing now will continue until 2007.

I use Diffraction Limited's *MaxIm DL* software to control the camera and capture about 20 to 30 images, which I then tile across the screen and whittle down to the six or eight best. I save them as FITS files under the current date. If the picture is of the solar disk without prominences, I choose the "FFT" (fast Fourier transform) option in *MaxIm DL* and then "hard process," using the histogram to enhance detail.

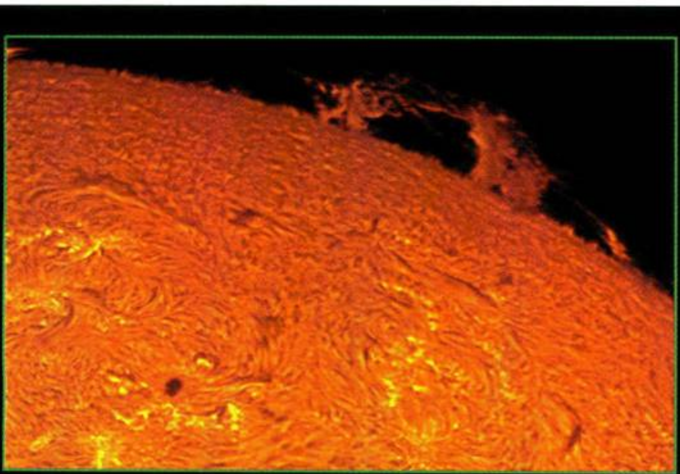
However, if the image contains a prominence, I repeat the FFT procedure twice to strengthen its impact and save the prominence image to a separate file. (Basically, I take a single image and process the disk and prominence separately, then put the two images back together again.)

I use Adobe Photoshop, my mainstay for digital processing. Starting with the disk image, I remove any of its fine dots by choosing "despeckle." Next, I sharpen the image and make three copies of it, each of which gets a single color: red, green, or blue. To produce a colored version, I combine the three images. At first, the result will look black and white because the colors were mixed equally; simply adjust the levels of each color. I remove all the blue and part of the green and then adjust brightness and contrast. If you're imaging only sunspots, you can print the result, and you're done.

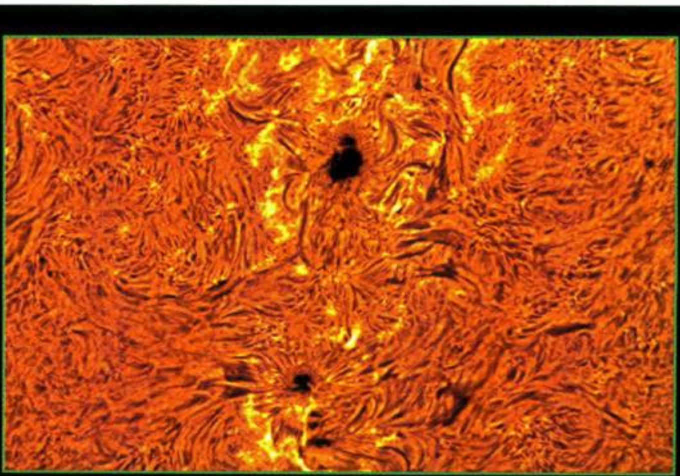
If you're combining disk and prominence images, make sure you're looking at the two images you want to superimpose (the disk in the prominence image should look overexposed, the result of maximizing the detail in the prominence). Use the wand tool to click on the edge of the Sun in the disk image so that a dotted line surrounds the disk — getting just the right place on the edge takes some practice. Then, click on "feather" to soften the edges (I choose a radius of 5) and copy this picture of the disk. Go to the image of the prominence, paste and align the processed disk image on top of the overexposed disk, and combine them digitally by flattening the image in the "layer" option.

Hα filters have allowed me to expand my observing into the light of day. If you can, try your hand at imaging the Sun this summer as it lingers longer in the sky than at any other time of the year. With practice, processing your shots will come as second nature, and you can marvel over the daily — and hourly — changes in the most important star in our sky. ■

To learn more about solar imaging, visit http://www.astronomy.com/toc



MAGNETIC FIELDS shield prominences from heating to the temperature of their surroundings. While the corona, the Sun's outer atmosphere, may reach a few million degrees, prominences may stay a hundred times cooler.



SUNSPOTS are regions of intense localized magnetic fields that often appear in groups. These were shot September 12, 2002. There will be about 50 sunspots this month, according to astronomers' forecasts.

Add a new dimension to your observing by appreciating the relative distances of celestial objects. /// BY JAMES MULLANEY

View the universe in 3-D

In ancient times, people looked to the sky and imagined a two-dimensional canvas stretched overhead, in which holes allowed the blazing light of the firmament through from beyond. Even now, knowing that planets, stars, and deep-sky objects lie along a vast range of distances, it's hard to look at the sky as the three-dimensional universe it is.

With the naked eye or even in a telescope, scenes typically get reduced to a 2-D plane that lacks the kind of dimension we would like to see.

But there are some techniques you can use and some particular objects you can view to accentuate the feeling of seeing the universe in 3-D. We notice depth in scenes because of the binocular vision of our two eyes and because of their separation. This parallax effect jumps out by means of a simple experiment. Place one finger against your nose, close one eye, and note your finger's position. Now alternate opened eyes, and you'll see the apparent position of the finger shift. If you move your arm so the finger is two feet in front of you, you'll see a smaller shift. At a point about 700 feet away, this parallax effect falls to zero — and with it the perception of depth.

So how do you see depth in astronomical objects? Several tricks and techniques can help out, with an array of objects — from the Sun and Moon to distant galaxies. The effects are psychological, and if carefully explored, can make observing the sky even more fun than it normally is. While these techniques work more strikingly with a binocular viewer on a telescope, they can all be seen through a traditional, single eyepiece. Low-power (30x to 60x) eyepieces should typically be employed to provide as much starry background around the objects as possible — with the exception of planets, which you'll get a better 3-D effect with at high power. Give 3-D viewing a chance, and let *Astronomy* know if you discover objects other than those mentioned here that provide notable examples of depth in the universe.

EARTHSHINE, the ghostly display of light reflected from Earth onto the Moon, cues the observer of the spherical lunar shape.

DAN SCHECHTER

Solar system wonders

Can you see the Sun in 3-D? Two cues provide a sense of looking at a huge globe of seething gases. One is limb darkening — the Sun is darker around its edges because the light there needs to pass through more solar atmosphere. The other cue is foreshortening or elongation of sunspots as they approach the solar limb (and their frequent seeming depression or "dipping" into the photosphere). These effects could not happen if we were viewing a flat, 2-D surface.

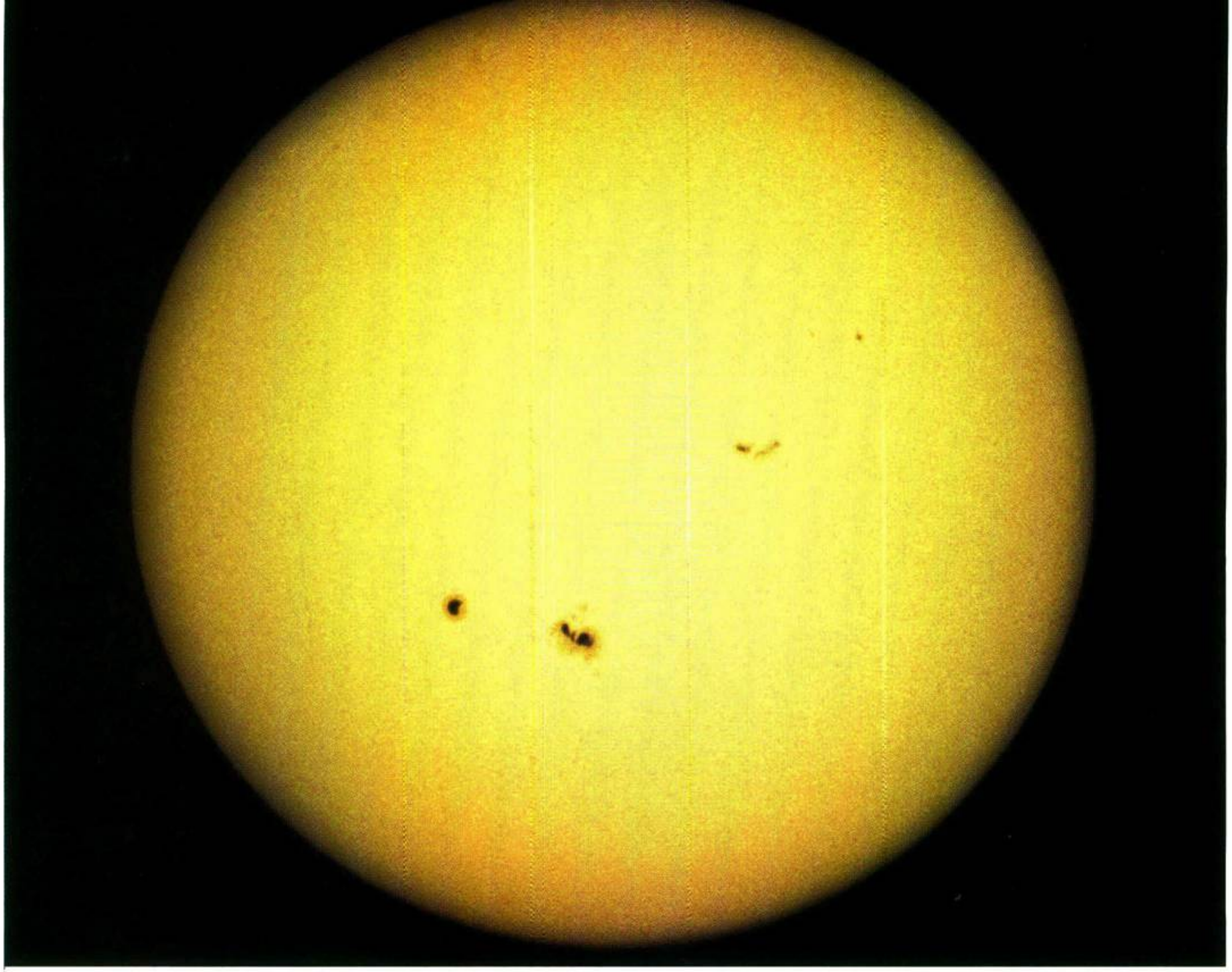
The Moon also gives the impression of being a huge globe, but mainly for a different reason. It's true that craters and seas show foreshortening toward the limb as with sunspots, but the big cue here is seeing the Moon hanging suspended against a backdrop of distant stars. This is especially striking during lunar occultations of big glittering star clusters like the Pleiades, Hyades, and Beehive.

When the Moon is in a crescent phase, its unilluminated portion is bathed in "earthshine." Moving ponderously eastward at roughly its own diameter each hour, the lunar globe slowly approaches and then passes over the stars behind it, sending the eye-brain combination an unmistakable message of seeing a huge sphere silently sailing through the vacuum of space.

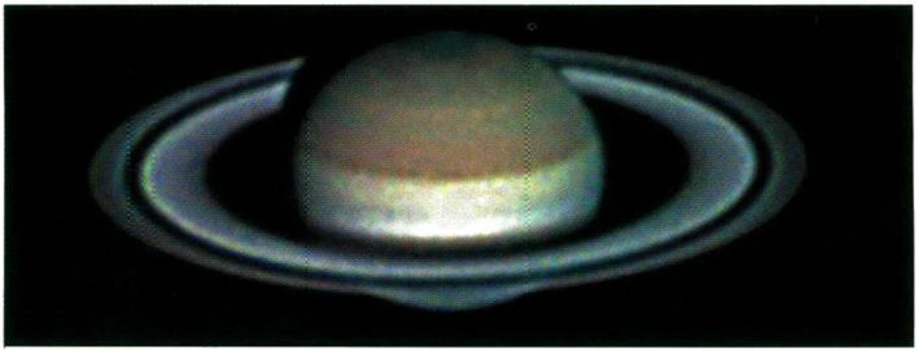
Another exciting aspect of moongazing is that of perceiving the vertical relief of the Moon's surface. This effect results from the shadows cast by mountain ranges, crater walls and central peaks, and other features, especially when they are on or near the terminator. Detecting vertical relief sends the eye-brain combo an unmistakable cue that these features are rising up at you (or dropping away from you in the case of deep crater floors and chasms). The effect is most dramatic around First Quarter Moon with the Sun's light coming in at nearly grazing angles, casting long shadows. At Full Moon, the effect has all but disappeared. With virtually no shadowing to be seen anywhere on its surface, our satellite does indeed then look like a flat world.

When the Moon occults one of the major planets — especially Jupiter and its retinue of satellites or Saturn and its majestic rings — the same striking illusion occurs since the brain "knows" the planets lie beyond the Moon.

A combination of limb darkening and/or phase angle results in an illusion of seeing



THE SUN'S LIMB DARKENING shows the falling temperature of the photosphere and is a prime indicator of viewing a gaseous ball. MARK COCO



SATURN'S RINGS passing behind and crossing in front of the giant planet help an observer view the depth of the suspended globe. JOHN CHUMACK

planets as three-dimensional balls at magnifications of at least 100x to 150x. Venus has a definite spherical look, especially when in the crescent phase, as does Mars when in the gibbous phase. But the effect is most dramatic with the four gas giants.

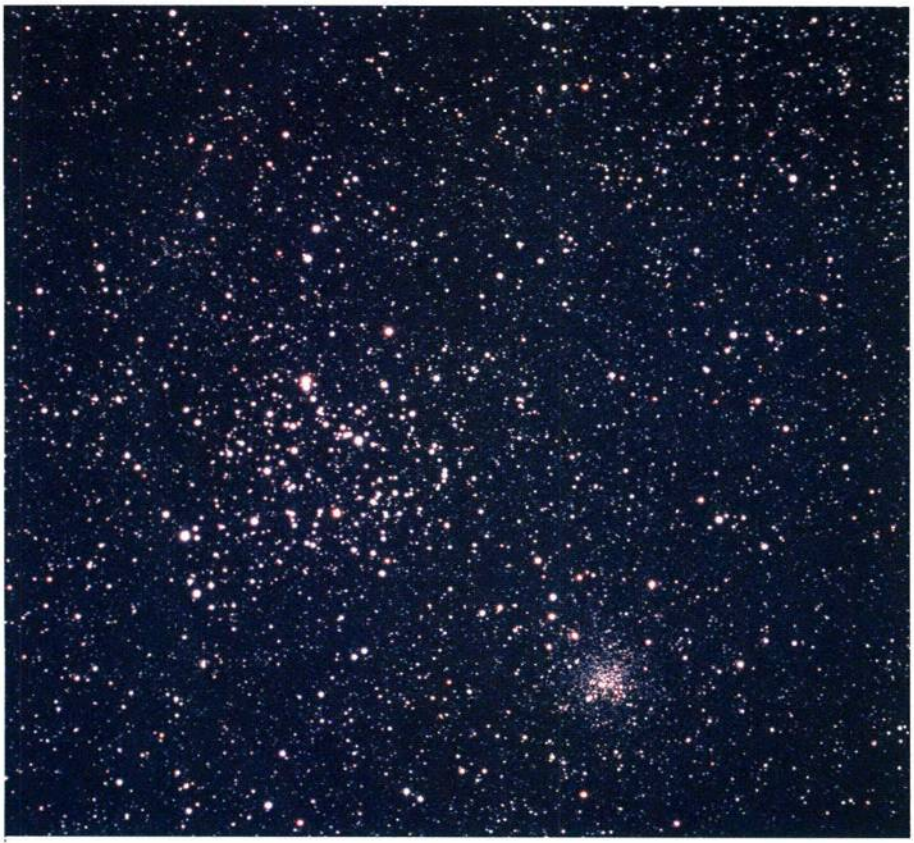
In the case of Jupiter, its Galilean satellites provide a sense of depth beyond that from the cue of obvious limb darkening resulting from its dense atmosphere. During occultations, the moons disappear behind its huge globe and later reappear at its other limb; during transits they cross in front of the planet, casting their dark shadows on the planet below them.

Saturn is the most three-dimensional looking of all the planets, thanks to its ring system. The effect strengthens with the globe's shadow on the rings behind it and the visibility of the planet through the rings themselves (primarily the Crepe Ring). Additionally, both planets display an obvious oblateness through their poles resulting from rapid rotation — another clear sign that we're observing rapidly spinning spheres.

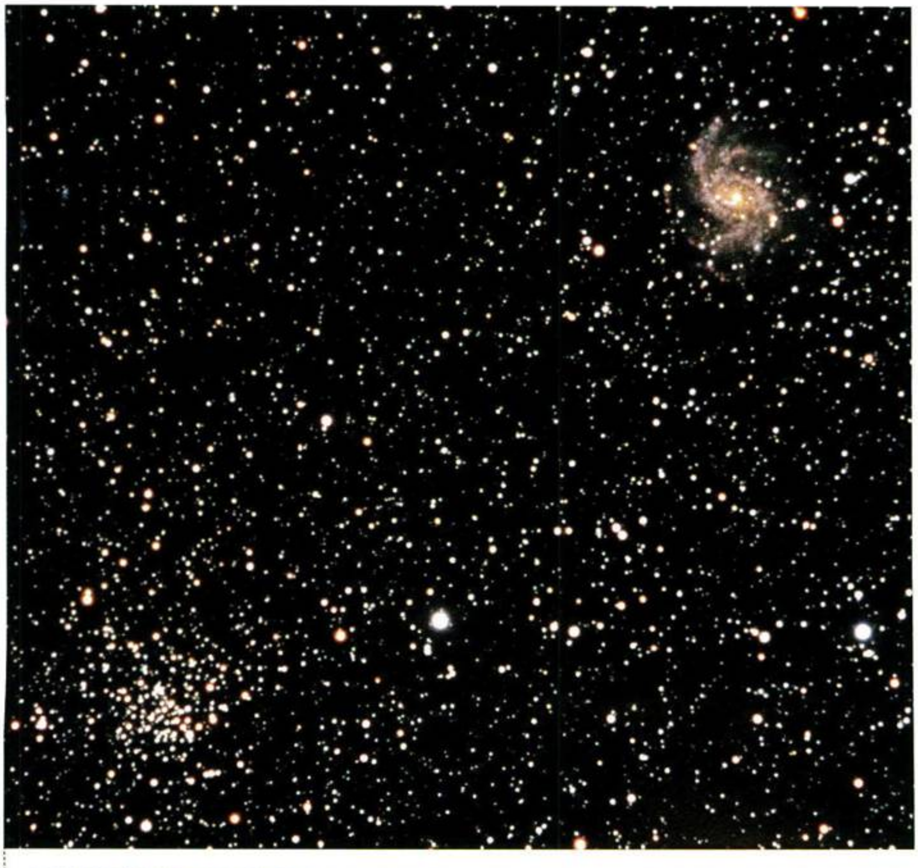
Uranus and Neptune generally require medium apertures (12 inches or more) and high magnification (300x and up) to show clearly the globing effect of limb darkening for most observers. Rounding out the solar system, large, bright comets often provide a sense of suspension in space as they pass through rich star fields. But in this case, they appear (at least to many observers) to float behind a curtain of foreground stars — demonstrating that the perception of depth is indeed illusionary.

Deep-sky wonders

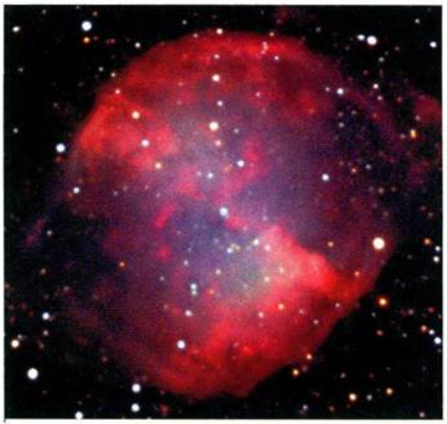
Many visual observers over the years have commented on the apparent sus-



M35 AND NGC 2158 fill the eyepiece with two open clusters neighboring one another. M35 (sparser, at left) suspends six times closer to Earth. ALBERTO LEVY



NGC 6939 (LEFT) AND NGC 6946, lying just 38' apart in the sky, are celestial targets that reflect little depth, yet lie millions of light-years from each other and an earthbound observer. CARL WEBER



THE DUMBBELL NEBULA, M27, a big, billowy celestial pillow, appears to float among the stars, yet lies farther away than the stellar curtain projected against it. GEORGE GREANEY

pension of certain deep-sky objects in space. Two of the most frequently reported of these are the Dumbbell Nebula (M27) in Vulpecula and the Ring Nebula (M57) in Lyra.

Small planetary nebulae generally don't have enough stars in front of them to show this effect. Nor do most galaxies, despite their appreciable sizes since they typically lie in star-poor areas. Among the few exceptions is edge-on galaxy NGC 891 in Andromeda, which in larger scopes is seen blanketed by a host of faint stars and seemingly floating in the celestial deep. Another is the magnificent Andromeda Galaxy (M31). Its immense nuclear bulge, obvious tilt toward our line-of-sight, and dark areas between its luminous spiral arms all combine to give the impression of seeing a colossal wheel suspended in the sky.

Some of the brighter double and multiple stars, despite being essentially point sources in the telescope, do provide a sense of depth if located in a particularly rich star field. Two of the most spectacular examples are the famed gold and blue pair Albireo (Beta Cygni) and the orange duo 61 Cygni, lying deep in the Milky Way star clouds. Another example is 145 Canis Majoris, often called the "Albireo of Winter."

Among the brighter emission nebulae, the Omega Nebula (M17) and the Lagoon Nebula (M8), both in Sagittarius, give the

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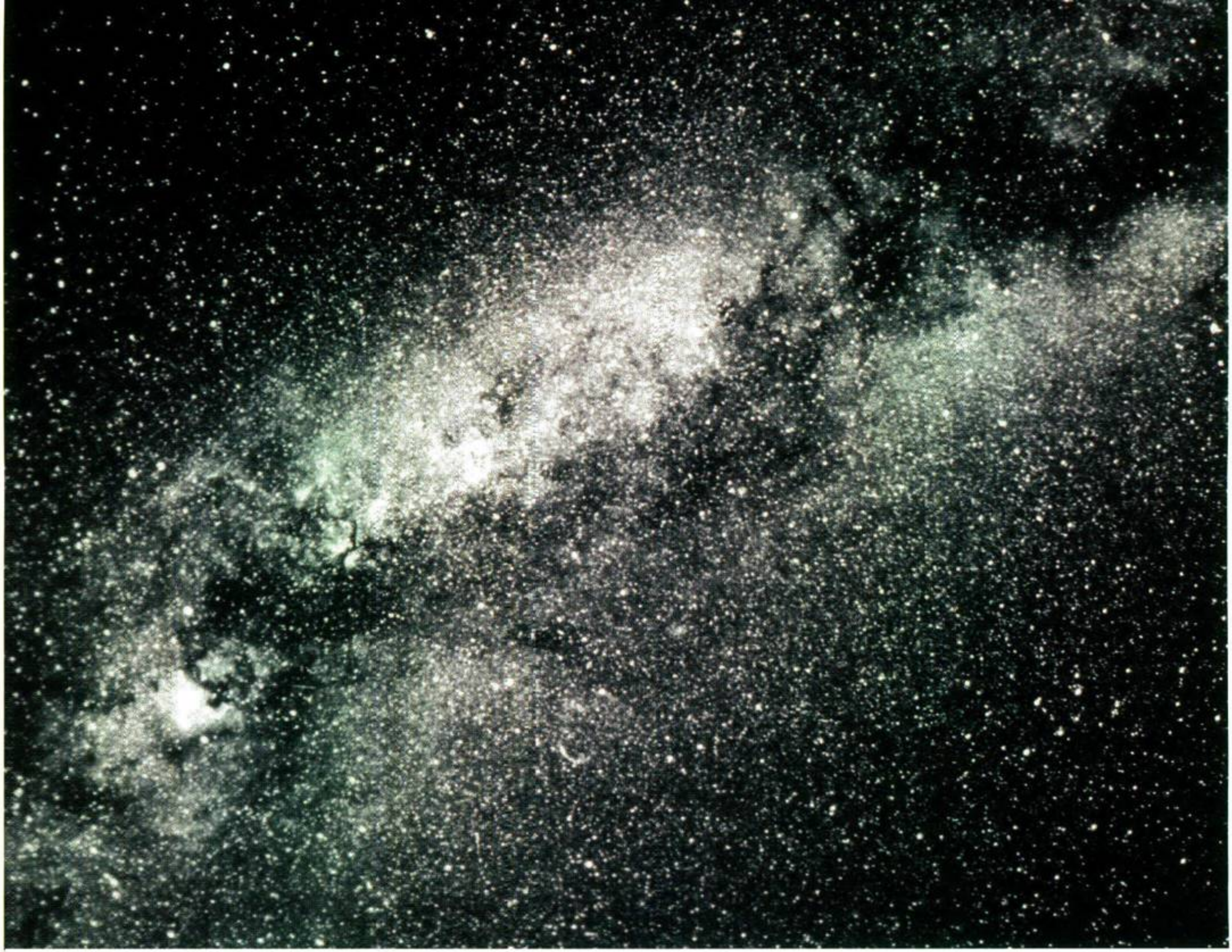
James Mullaney *has written more than 500 observing-related articles and the book* Celestial Harvest: 300-Plus Showpieces of the Heavens for Telescope Viewing & Contemplation *(Dover Publications, 2002).*



IN THE MILKY WAY'S BLANKET of stars, brighter stars are closer to an observer, while dimmer, more distant ones lie far beyond them. CHRIS COOK

visual impression of floating beyond a curtain of stars. The spectacular Orion Nebula (M42) not only has stars sprinkled over the top of it, but also embedded within. The most obvious of these is the well-known multiple sun Theta^1 (θ^1) Orionis, the Trapezium. Viewing the Orion stellar nursery with a low-power, wide-field eyepiece in a 6-inch or larger glass on a dark, moonless night shows wings encircling the heart of the nebula. This provides a distinct sense of looking at a huge three-dimensional radiation-blown cavity or bubble.

Open star clusters don't seem to benefit as much from rich star fields as nebulae because they are already filled with stars. But where two objects happen to lie within the same eyepiece field — one near and bright, the other faint and remote — a sense of depth again comes into play. One of the best examples is Lassell's Delight (M35) in Gemini. This big, splashy stellar jewel box sports a dim circular glow shining through it at about a half degree to the southwest. This open cluster is NGC 2158, visible through a 3- to 4-inch scope on a dark night. At some 16,000 light-years from us, it lies more than six times the distance of the cluster in front of it. Once you hand off this cue to the brain, M35 will definitely look suspended against its background. An even more extreme example is the cluster-galaxy pairing NGC 6939 and NGC 6946 in Cepheus. The 8th-magnitude cluster is 4,000 light-years from Earth, while the 9th-magnitude galaxy lies some 10 million light-years away.

As for depth perception in globular star clusters, anyone who has ever seen the magnificent Hercules Cluster (M13), or Omega Centauri, through a 10-inch scope at 150x or more will readily agree that they were beholding a vast spherical swarm of stars — a colossal ball of glittering suns suspended three-dimensionally before them.

The Milky Way

Although the effect described for viewing our home galaxy can be experienced to some extent with telescopes and binoculars, it is best seen using the "all-sky" observing capabilities of unaided eyes.

On a dark, moonless night, preferably in late summer or early fall, look at the big, billowy star clouds of the Milky Way in Cygnus, Scutum, or Sagittarius. Realize that you are seeing layer upon layer of stars. Once the eye-brain combination accepts this cue, our magnificent Milky Way jumps out of the sky at you.

Sir William Herschel pointed out long ago that as stargazers we must "learn to see" — in essence that we need to educate the eye-brain combination. Teaching it to see depth where none actually exists using the cues listed will add a new dimension to your observing experiences. ■

For more about depth in observing, visit http://www.astronomy.com/toc.

Astronomy test-drives a telescope . . . in broad daylight. /// BY JOHN SHIBLEY

Coronado's NearStar scope

I've discovered an outstanding telescope that works lousy at night. This may seem like a contradiction, but it's not if the star you are most interested in happens to be the Sun and the telescope is Coronado's NearStar. Designed specifically for solar viewing, this 70mm (2.8-inch) f/5.7 refractor opens up a whole new time of day for observing.

You may have already looked at the Sun safely through a common solar filter that slips over the front of a telescope and conveys a visible-light view. NearStar works along similar lines, but instead of a nighttime scope adapted for solar observing, it's essentially a telescope built around a hydrogen alpha, or Hα, solar filter. This means that NearStar doesn't present an average, humdrum view of the Sun. Instead, it lets you view our home star in all of its dynamic glory, with vivid detail, through well-matched optics.

> The Sun through an Hα filter looks like our nearest star ought to – rich, majestic, alive, and everything we ever imagined.

Music of the sphere

To understand why this scope is so different, let's explore an analogy. Ever try this at a concert? The entire orchestra is playing a favorite symphony, and the sounds blend together to form a coherent melody that's instantly recognizable. Let your ear get drawn to the bass section as it lopes along in the orchestra's lower range. You may notice for the first time the basses' role *in defining* the music's acoustic shape. Suddenly, you're not just hearing a distinct section but sensing a piece of music transforming itself into an entirely different feel, if not sound. You've stumbled into the world of the sublime and discovered an entirely new side to a symphony that will never sound quite the same again.

Now, cut to the Sun. Observers safely scrutinize its face time and again with relatively inexpensive solar filters that slip over a telescope's front end. The solar surface looks grainy and is pocked with sunspots. This is how our home star looks in white light — an amalgam of colors that blends like individual sounds of an orchestra to convey the scene through an eyepiece.

But what if you could tune into a visual sweet spot, or section, along the Sun's spectrum to discover the sublime? Such a sweet spot exists, and it's Hα, a narrow zone in red light emitted by hot, ionized hydrogen gas. With an Hα filter, all wavelengths of light are blocked except for this ever-so-narrow region nestled within the solar spectrum. Not surprisingly, observing the Sun in Hα reveals our star as you've never seen it before, in quite literally a whole different light.

The Sun according to Hα

An Hα filter is so effective because it peers into an active area within the Sun's chromosphere where hot hydrogen gas churns and rolls along lines of strong magnetic fields. All this action usually gets lost due to the brilliance of the photosphere, a diffuse region of hot gas that lies directly in our line-of-sight to the chromosphere. But, just as fishermen don polarized sunglasses to cut through glare on the surface of a river to scan the bottom for fish, solar astronomers use Hα filters to slice through the photosphere's din to observe the wealth of detail below.

And what wealth it is.

Sunspots that look like one-dimensional tracts of black and gray in white light blossom into rich eddies of structure. Light splotches, called plages, surround the sunspots as they huddle in groups or plant themselves individually here and there along the Sun's girth.

Even our Sun's normally lackluster, grainy appearance transforms into a rich network of light and dark swirls, which appear like the fibers of a giant writhing muscle. The view through an Hα filter proves that the Sun is indeed a seething cauldron of super-hot hydrogen gas.

Aside from beautifully defined sunspots, other, softer features shine in Hα light. Prominences — graceful arcs of gas erupting off the Sun's surface

John Shibley *enjoys photographing and observing the Sun when the clouds don't block his Michigan Upper-Peninsula view.*

BEAUTIFUL TO LOOK AT, and beautiful to look through, Coronado's NearStar reveals views of the Sun that simply "wow." WILLIAM ZUBACK

NEARSTAR
video head
fluid - system
MADE IN W.-GERMANY
120 100 80 60 40 20 0

A RED BLOCKING FILTER is built into the standard 1¼″ diagonal eyepiece holder. This limits the field of view to no more than 1.5°, or three solar diameters, regardless of eyepiece type. R. KEMPTON (NEW ENGLAND METEORITICAL SERVICES)

along magnetic field lines — blaze into view and are often associated with sunspot groups. These plasma fountains are so faint that we notice them only along the Sun's limb where they emerge against the darkness of space.

In Hα, prominences that project along our line of sight appear as dark, sinuous threads silhouetted against the solar face. This tells us something important — the erupting gas is cool. Cooler regions on (or seen against) the Sun always look darker. The prominences are huge — a single tongue of gas could enshroud several Earths.

NearStar 101

To reveal these sights, NearStar's Hα solar filter does three things. The telescope's front element knocks down the Sun's light with a deep red "energy rejection" filter that dramatically reduces solar heat, intensity, and ultraviolet energy. The light that passes through this filter then travels down the tube into an "etalon" (see "Restricting light," page 89) that reduces it to wavelengths around Hα. The final component in the filter complex, a right-angle diagonal on the end of the scope, has an integrated blocking filter that subtracts all remaining non-Hα light. This diagonal accepts standard 1¼″ eyepieces.

Incidentally, for obvious reasons of function and safety, the diagonal is permanently built into the telescope's rear tube and can't be removed — even intentionally. Its 1-inch range of motion helps accommodate most eyepiece designs and offers focusing flexibility during photography.

The etalon technology found in NearStar is what makes it unique among other amateur equipment. Observing the Sun in Hα light is nothing new; astronomers have been doing it for decades. What is new, however, is the technology that Coronado incorporates into this and other Hα systems they manufacture.

Until as recently as the last five years, Hα filter assemblies not only utilized more complex designs; they also had to be heated to a certain temperature to function well. This made them complicated and expensive.

Coronado's etalon technology is literally a spin-off of Star Wars research. The NearStar's etalon filters the necessary Hα wavelength to within one-tenth of a nanometer over a temperature range of 32° to 100° F. All these innovative optics hide within an attractive, all-aluminum tube that is less than 1.5 feet long.

Under a Sun-splashed sky

What happens if you observe on days that are outside of NearStar's ideal temperature range? Theoretically, at least, its filter should transmit a wavelength band slightly wider than the Hα sweet spot. While the Sun might still appear sharp, some delicate details in prominences and plages might not appear as distinctly. I checked this for myself during some sunny, chilly December days.

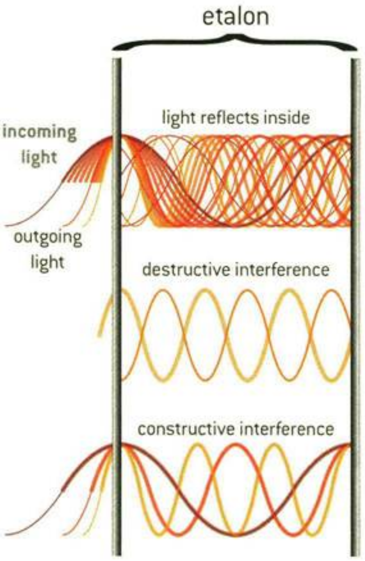
What I found surprised me. Even though a thermometer in the shade read 5° F, features on the Sun, even under the scrutiny of 100x, still looked crisp and distinct. The likely explanation is that heat inside the tube kept the etalon assembly within its ideal operating range. I'd be curious to see what happens in temperatures over 100° F.

NearStar comes with a clamshell-style tube ring. Its base includes a ¼-20 socket hole that mounts on any beefy photographic or spotting scope tripod. Because this tube ring is identical to one that Tele Vue ships with its small Pronto refractor, I was able to take my Pronto's baseplate and transfer it to the NearStar's ring. This let me put the scope on Tele Vue's Panoramic mount.

/// RESTRICTING LIGHT

ETALON FILTERS consist of two parallel surfaces that allow only light with certain wavelengths to pass through. Light enters through one side of the system, and if it has a wavelength that evenly fits between the two surfaces, it will reflect constructively and pass through the etalon. If the light's wavelength doesn't fit evenly between the surfaces, the light waves destructively interfere, and the light cancels out inside the filter.

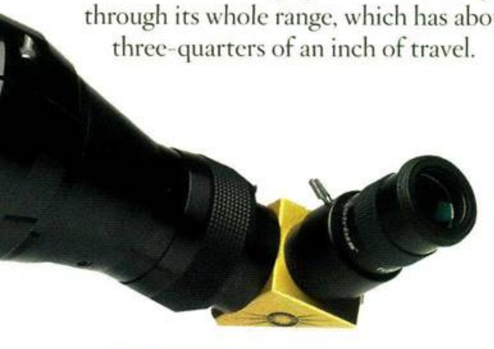
The coatings on the surfaces can also restrict the types of wavelengths that reflect within the etalon and pass through its surfaces. By carefully tuning the separation between the surfaces and the reflective properties of their coatings, very narrow passband filters can be constructed.



Fitting holes on the rings also accepted Tele Vue's nifty "Sol Searcher" Sun finder device. (See "Focus on finders," *Astronomy*, March 2003, for more on the Sol Searcher.)

From a practical standpoint, however, finding the Sun with NearStar didn't require a finder. All I did was aim the scope at the Sun until the tube's shadow was at its shortest. This works regardless of how low a power, or wide an eyepiece design, you use. The shortened-shadow technique landed Sol in the field of view every time. Incidentally, the blocking filter's 10mm-wide opening located in the diagonal yields just over 1.5° of sky, or three solar diameters.

NearStar's rear cell incorporates a focuser that you twist to focus images in the eyepiece. This "helical focuser" is an oversized knurled grip that turns easily through its whole range, which has about three-quarters of an inch of travel.



THE LIGHTWEIGHT NEARSTAR is easy to carry on a shoulder and mount on a standard camera tripod. WILLIAM ZUBACK

Getting high, within reason

Daytime observing presents a whole different set of considerations compared to nighttime observing. Wider-field eyepieces offer exit cones of light optimized for night use. These designs reflect the fact that at night an eye pupil dilates to around 6mm. During the day, however, pupils contract to around 3mm, which may narrow the range of useful eyepieces. Coupled with NearStar's f/5.7 optical system, eyepieces with focal lengths longer than 17mm will produce light-exit cones wider than what daytime pupils can handle.

How high a power can you achieve? That all depends upon how steady the air is between you and the Sun. Things around you like roofs and buildings continually reradiate the heat they absorb during the day. If you observe from an area that's thermally stable, like a field of grass or near a stand of trees, the seeing will be better. Trees and grass are busy absorbing the Sun's energy for photosynthesis, not shunting it away like an inanimate hunk of pavement. Some solar observers have found that observing over a lake — better yet being surrounded by water, such as on a peninsula or on an island — also improves image quality.

The general rule of thumb when using high magnification in any telescope is not to exceed 50x per inch of aperture. For the 2.8-inch NearStar, this translates to around 140x, the magnification offered by a 3mm eyepiece.

Photography through a NearStar is as easy as putting a digital camera up to the eyepiece and snapping a picture. A variety of vendors sell adapter rings for eyepieces with eyecups that unscrew to attach most makes of digital and video cameras. Bear in mind that NearStar is, in spirit, a low-power solar spotting scope. In my opinion, shooting detailed photos of the Sun through a small, quick-setup package like the NearStar almost seems like an oxymoron. If you want to do detailed solar photography, buy a bigger scope and plunk it on an oversized mount fitted to a pier.

Hα observing purists may also prefer a "tunable" version of NearStar's filter design. Tunable filters capture a slightly wider variety of solar features. Coronado's MaxScope 60, with its slightly smaller aperture, offers this option.

To a NearStar Sun

So why buy a dedicated solar scope? The NearStar offers instant gratification in a package small enough to fit over a shoulder, but powerful enough to deliver the Sun the way it was promised to us in science class. The Sun's Hα face, laced with delicate prominences, literally changes by the hour. Scientists often lapse into superlatives when they describe it, offering to our imaginations structures thousands of miles high and heated to millions of degrees. The Sun through an Hα filter looks like our nearest star ought to — rich, majestic, alive, and everything we ever imagined.

Not bad for a scope that shows nothing in a night sky. ■

NearStar Solar Telescope

Aperture: 70mm (2.8 inches)
Focal length: 399mm
Focal ratio: 5.7
Tube length: 17 inches
Telescope weight: 10 pounds
Price: $3,348

Coronado

601684 S. Research Loop, Suite 524
Tucson, AZ 85710
[t] 520.740.1561 or 866-SUN WATCH
[f] 520.624.5083
[e] info@coronadofilters.com
[w]www.coronadofilters.com

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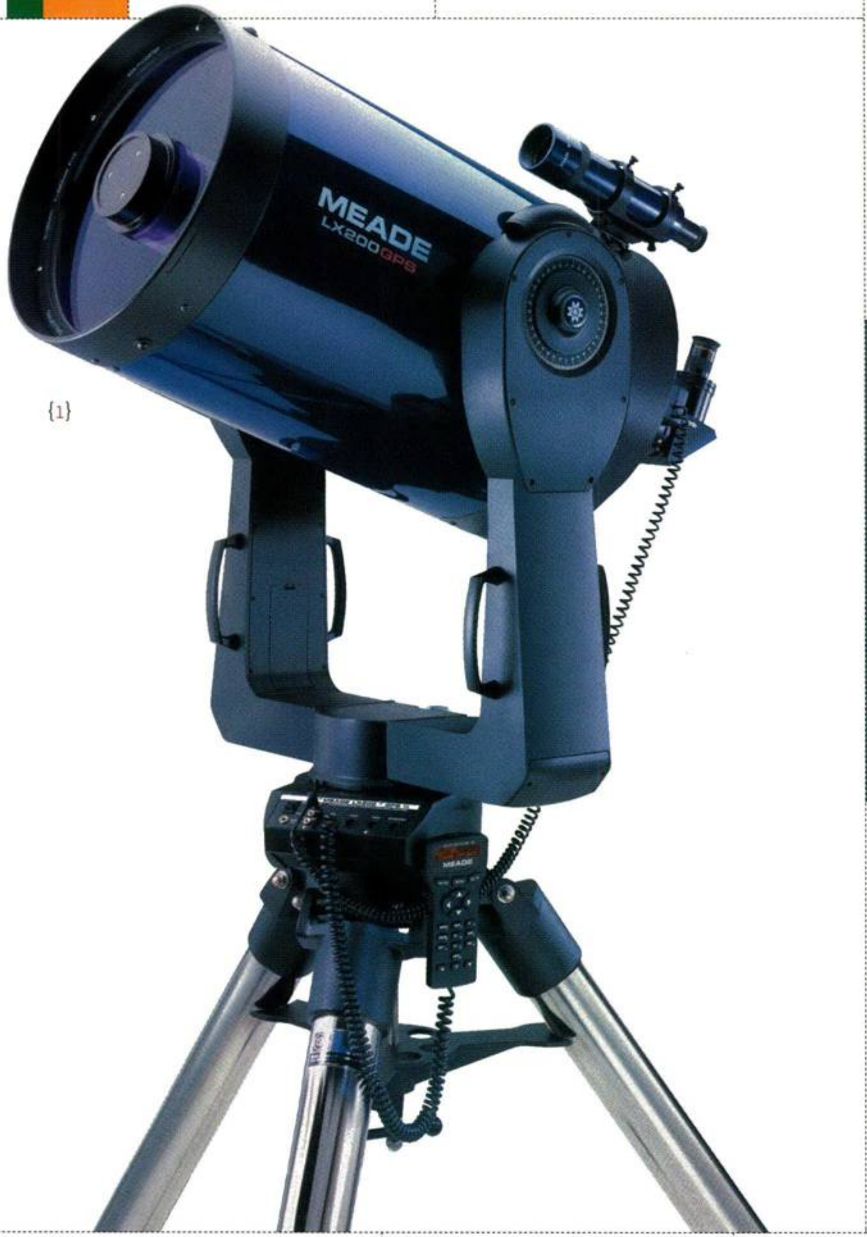

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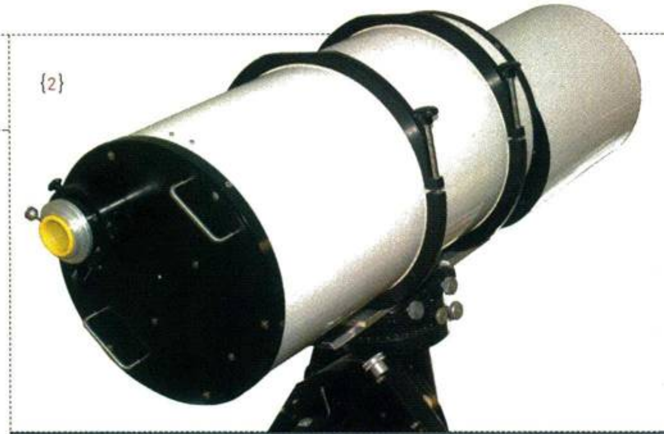

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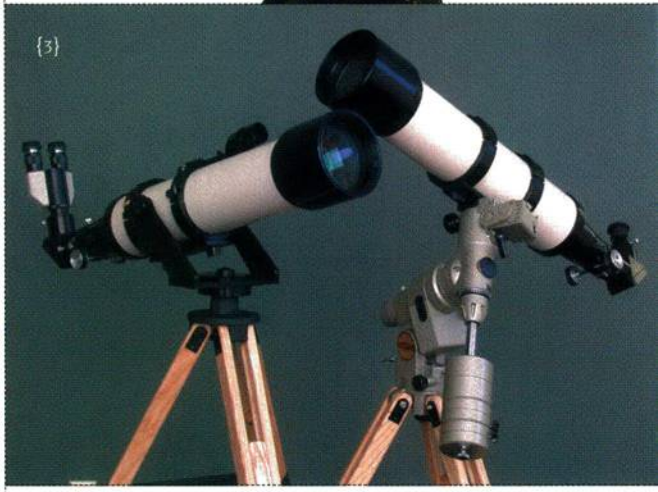

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TELE VUE 41mm PANOPTIC

1. Meade 14-inch LX200GPS Schmidt-Cassegrain

The latest in Meade's LX series, the new 14-inch collects 96 percent more light than its 10-inch brother. This f/10 go-to scope can slew to 145,000 objects on both axes simultaneously, at any of 185 drive speeds. The tube assembly includes a primary mirror lock, microfocuser, fork mount, tripod, 8x50mm finder, 2" diagonal, and a 26mm Super Plössl eyepiece.

$4,295; Meade
6001 Oak Canyon
Irvine, CA 92618
[t] 800.626.3233
[w] www.meade.com

2. APM Telescopes' 10-inch f/9 folded TMB apochromatic refractor

Light travels 89 inches inside this custom-made scope, although the tube is only 27 inches long. It owes its svelte size to two mirrors, each precise to 1/20 wave, that bounce the light between them before letting it escape through the eyepiece. This high-end apochromat comes with dew shield, medium-format focuser, tube rings, and grating.

$44,900; APM Telescopes
Goebenstrasse 35
66117 Saarbrücken; Germany
[t] 49.681.954.1161
[w] www.apm-telescopes.de

3. Tele Vue NP127 refractor

For an excellent telescope that's easy to carry and set up, try Tele Vue's new NP127. This 5-inch, f/5.2 apochromatic refractor has four elements and produces flat-field views at a crisp resolution of 0.9". Weighing 14 pounds, the limited-production model NP127 comes with a sliding dew shield, tube rings, a 2" star diagonal, an adapter for 1¼" eyepieces, and a foam-lined case.

$6,000; Tele Vue Optics, Inc.
32 Elkay Drive
Chester, NY 10918
[t] 845.469.4551
[w] www.TeleVue.com

4. Tele Vue Bandmate OIII filter

Forget seeing the world through rose-colored glasses — the views are better in green. This filter, the first in a new series, maximizes light transmission in two narrow bandpasses, blocking light pollution while enhancing the green doubly ionized oxygen lines emitted by nebulae. Optical-quality glass helps prevent image distortion, even with a high-magnification diagonal.

$220 for 2"; $125 for 1¼"
Tele Vue Optics, Inc.; 32 Elkay Drive
Chester, NY 10918
[t] 845.469.4551
[w] www.TeleVue.com

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ISS-AT Image by Richard Berry

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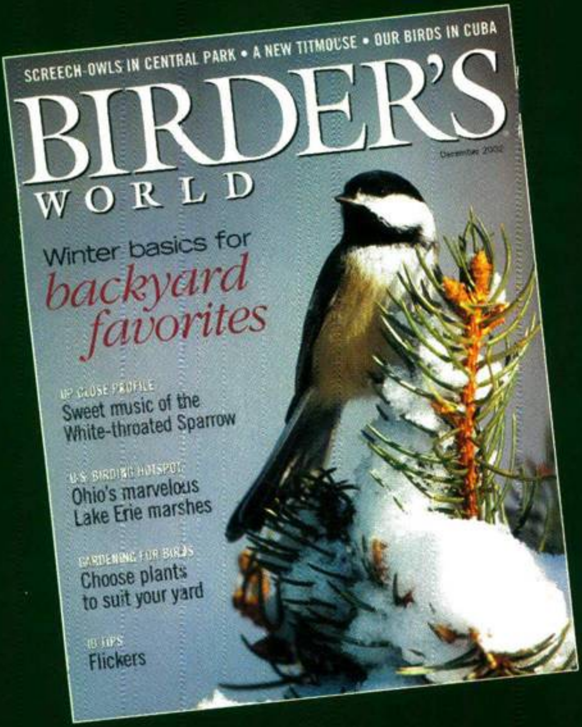
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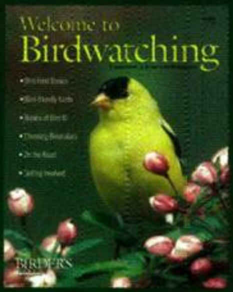
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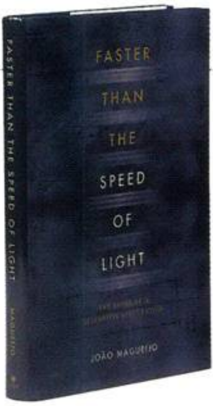

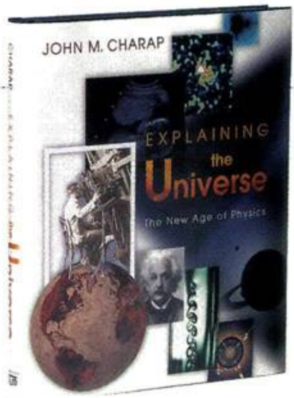

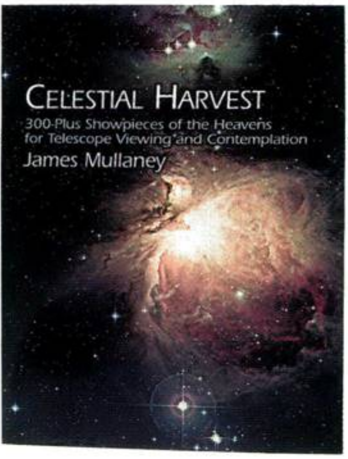
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James Mullaney

Faster than the Speed of Light

João Magueijo, 288 pages, Perseus Publishing, Cambridge, Massachusetts, 2003; ISBN 0-7382-0525-7; hardcover, $26.

With all the attention João Magueijo has been getting in the press, I wasn't sure that the title didn't refer to him. Of this theoretical physicist at Imperial College, London, the new-wave start-up science magazine, *SEED*, recently wrote, "The heir apparent to Einstein's kingdom looks like a Gap ad." At first I was tempted not to review his book because of the overexposure that he and his variable speed of light (VSL) idea have had, attention far exceeding any success or influence the idea has achieved in the scientific arena.

But then, crazy new ideas — and iconoclastic individuals — are needed when confronting the toughest puzzles in science. It is impossible to know ahead of time which ideas will pan out (or which of the many bright young scientists will become stars). The leaders of the field are, more often than not, too skeptical, having seen so many ideas fail, while newcomers are blinded by their own enthusiasm. Even mathematical beauty, often invoked as a guide, is faulty: The rubbish heap of ideas is piled high with beautiful theories killed by ugly facts (take, for example, Fred Hoyle's steady-state cosmology).

Faster than the Speed of Light is the story (some might say rant) about the birth of a paradigm-challenging idea, written by its young, still immature proponent. The idea of VSL is simple: Einstein's famous speed limit changes with time and was higher in the past than it is today.

The motivation behind the theory is to find an alternative to inflation for why we live in such an orderly universe. While the tiny variations — 0.001 percent — in the intensity of the cosmic microwave background (CMB) have dominated the headlines over the past few years (including the beautiful Wilkinson Microwave Anisotropy Probe results announced in February), just as striking and more puzzling is the CMB's remarkable evenness — it is uniform to 99.999 percent. That's like finding a pebble smooth to ball-bearing curvature, and it raises a deep question — why is our universe so uniform?

In standard Big Bang theory, this well-known puzzle is called the horizon problem: Unless the early universe had a very smooth structure, it would not have had sufficient time to iron out its kinks because of cosmic expansion and the constancy of the speed of light.

Inflation solves the horizon problem by postulating a very short period of very rapid expansion very early on. Magueijo's theory posits that the speed of light was greater in the past than it is today, so that it is possible to smooth things over distances that look impossibly large now.

Inflation is very well developed and makes three testable predictions: a spatially flat universe, a particular form for the hiccup in density that seeded all structure and gave rise to the tiny fluctuations in the CMB, and a cosmic sea of gravitational waves. There is now good evidence to support the first two.

VSL has not been developed sufficiently to make sharp predictions. But one intriguing bit of evidence from the spectra of faraway quasars hints that the fine-structure constant, a measure of the force that determines how certain charged particles interact with light (now estimated to be about 0.0073), was slightly smaller in the past. If true, this could be a smoking gun for VSL. (If the speed of light varies with time, it is likely that some of nature's constants do, too.)

In theoretical physics, as in other realms, risk and reward are related — to solve big problems you need bold ideas. The universe presents some of the tallest problems. VSL is risky and bold; time will tell if it is correct.

Magueijo's story is fresh, raw, and completely unbalanced, which is part of its charm. It has something bad to say about just about everyone — referees, editors, colleagues, anyone over 40, and institutions, including British universities, tenure, and the Aspen Center for Physics (where I have been a trustee for 20 years). As a history of one of the most exciting periods of cosmology ever it fails badly. But it does provide an interesting perspective — a kind of *Fear and Loathing in Las Vegas* meets *A Brief History of Time* — on the inner workings of one of the most mysterious professions, theoretical physics. — **MICHAEL S. TURNER** *is chair of the astronomy department at the University of Chicago and a pioneer in fusing cosmology and particle physics to study the earliest moments of creation.*

Explaining the Universe: The New Age of Physics

John M. Charap, 272 pages, Princeton University Press, Princeton, New Jersey, 2002; ISBN 0-6910-0663-6; hardcover, $29.95.

"The discoveries made by physicists during the last hundred years, and their applications in medicine, industry, and the home, have transformed our lives," Charap tells us at the start of *Explaining the Universe*. But this is more than a simple history of physics — it is the story of our changing view of the universe.

John Charap, a theorist at Queen Mary and Westfield College in London, begins with a retrospective of physics at the turn of the 20th century, examining the central questions physicists faced. This is a wonderful setup for the remainder of the book, in which he leads readers to the development of Einstein's relativity, the search for the structure and composition of the atom, and string theory. He finishes by discussing the origins of the universe and offers some admittedly rash predictions, giving, for example, 2010 as the date by which the masses of the three types of neutrinos will be known.

The text seems ideal for a college-level "physics for poets" course, as Charap avoids math, with the exception of exponents in numbers. Given the breadth of material he covers, it is not surprising that many topics are treated superficially. But he does offer suggestions for further reading, as well as a brief glossary of technical terms.

While there are a number of photographs, line drawings, and plates, several subjects would have benefited from more illustrations. As a caveat to *Astronomy* readers, despite its title, *Explaining the Universe* is really a physics book with some astronomy and astrophysics woven in. But it's an engaging read, and it offers perspective on what Charap describes as the last century's "profound changes in the way we understand the universe."
— IGNACIO BIRRIEL *teaches physics at Morehead State University in Kentucky.*

Celestial Harvest: 300-Plus Showpieces of the Heavens for Telescope Viewing and Contemplation

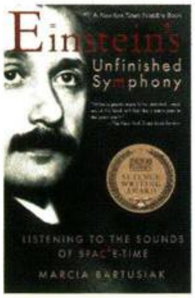
James Mullaney, 103 pages, Dover Publications, Mineola, New York, 2002; ISBN 0-4864-2554-1; softcover, $11.95.

This book was written by an enthusiastic observer whose passion for the subject is contagious — readers will be inspired to go outside and study the sky.

Mullaney's main interests here are visually spectacular stars and deep-sky objects that can be viewed from mid-northern latitudes. These are ordered alphabetically by constellation.

Each entry contains concise information for easy field reference. Arranged on the left-hand side of the page are the object's type, right ascension and declination, magnitude, spectral type (if appropriate), and angular size, or, in the case of double or multiple stars, separation. Comments from noted observers and descriptions of the views from small- and medium-sized telescopes fill the rest of the page. And because nearly all of the author's observing sites were located in areas of moderate to heavy light pollution, the book offers targets that are within sight of most suburban skygazers.

Lively and accessible, *Celestial Harvest* is peppered with astronomical quotations that evoke the majesty of observing. It's a handy guide for nights beneath the stars, but when clouds foil your plans, the descriptions of stars and deep-sky objects make for interesting armchair reading.
— IAN BIRRELL *observes the sky from his home in Cheltenham, England.*



Einstein's Unfinished Symphony: Listening to the Sounds of Space-Time

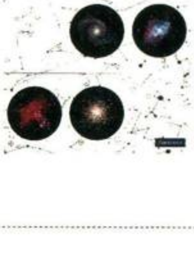
Marcia Bartusiak, 272 pages, Berkley Books, New York, 2003; ISBN 0-4251-8620-2; softcover, $14.

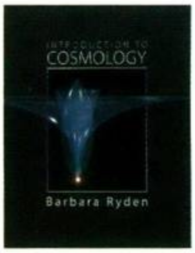
In this new paperback edition, readers are wooed to the potentially off-putting subject of gravity waves with the siren song of Bartusiak's award-winning writing. Likening exploding stars to cymbal crashes and spinning pulsars to drumbeats, she explains how violent cosmic events may cause vibrations to ripple through space-time and how sensitive instruments are straining to hear them.

The Observing Guide to the Messier Marathon: A Handbook and Atlas

Don Machholz, 172 pages, Cambridge University Press, New York, 2002; ISBN 0-5218-0386-1; hardcover, $25.

Eventually, almost every ambitious observer attempts one of astronomy's hallowed rites of passage: the Messier Marathon. Named after French comet hunter Charles Messier, the feat involves viewing all 110 galaxies, star clusters, and nebulae that comprise the Messier Catalog — in a single night. This book furnishes more than 90 star charts to help you find your speedy way through the list and offers background on Messier himself.





Introduction to Cosmology

Barbara Ryden, 300 pages, Addison Wesley, San Francisco, 2003; ISBN 0-8053-8912-1; hardcover, $54.

This upper-level undergraduate textbook spans the study of our universe with concise writing, clear illustrations, and even a poem by John Updike. Because (as the author puts it) "ruthless simplification" is required, each chapter concludes with a list of suggested readings for deeper exploration. Although the book is crammed with equations, general readers may enjoy flipping through it because of its scope and clarity. Recent discoveries such as the accelerating expansion of space keep the text up-to-date.

Max Goes to the Moon: A Science Adventure with Max the Dog

Jeffrey Bennett, illustrations by Alan Okamoto, 32 pages, Big Kid Science, Boulder, Colorado, 2003; ISBN 0-9721-8190-3; hardcover, $16.95.

This children's book stars a space-faring dog that howls in the direction of the Moon during a parade in his honor and thereby galvanizes support for another Moon landing (which leads, naturally, to a lunar colony). Improbable though it may seem, this story of Max the dog covers a fair bit of science, from the Moon's weaker pull of gravity to the cause of lunar phases. Children may find a new hero in this canine cosmonaut, who is based on the astrophysicist author's Rottweiler.

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TV-76, 3" f/6.3 apo	**1675⁰⁰**
Pronto, 2.7" f/6.8 semi-apo	**1120⁰⁰**
Ranger, 2.7" f/6.8 semi-apo	**695⁰⁰**

Three of the newest TeleVue eyepieces are the 2.5mm, 3.5mm, and 11mm 1.25" Type 6 Naglers at $280 each. There's also a new 2" 41mm Panoptic at $495.

There's a new $840 BinoVue without image amplifier that's designed for use with long back focus Schmidt and Maksutov Cassegrains.

And TeleVue now has 1.25" light pollution filters at $125 each (2" versions are $215).

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Meade 8" SN-8EC f/4 reflector ($824 w/UHTC)

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Meade 8" LX90

Meade prices are about the same anywhere you call. So why order a Meade scope or accessory from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not if you can usually get the Meade you want from stock . . . right now . . . at the right price . . . right here at ***astronomics***.

The **Meade LX90** lets you enjoy go-to astronomy for not a lot of money. UHTC (Ultra High Transmission Coatings) optics provide up to 20% brighter images for only $175 additional. Both standard and UHTC scopes come with a heavy-duty adjustable height tripod, an Autostar computer with a 30,223 star and object memory, an 8 x 50mm finderscope, and a 26mm Super Plössl eyepiece.

We usually have the LX90 in stock (both standard and UHTC versions), so you can probably get *your* LX90 with little or no delay. If Meade is shipping the LX90 *(or any Meade telescope)* for a dealer to keep in stock, chances are good we *have* it in stock.

Vixen products available from stock.

For years, high quality Vixen telescopes and accessories from Japan have been best-sellers in Europe. Now, Vixen is also available in the U. S. – imported by TeleVue, a company with a sterling reputation for quality of its own.

Whether it's a telescope, a German equatorial mount, or a visual or photographic accessory, if it's from Vixen, chances are good we have it in stock. All the Vixen Lanthanum long eye relief and wide angle long eye relief eyepieces are ready to ship. Also in stock are the well-known Great Polaris and Great Polaris DX mounts to use with your own optics. If you want optics that are out of the ordinary, we carry Vixen's fluorite, ED glass, and dual ED apochromatic refractor optical tubes and complete scopes. You can check our website for a complete listing of available items or you can call us toll-free at (800) 422-7876 and see for yourself.

Vixen GP ED102S 4" f/9 ED apo refractor (with optional drive)

A whole lot less shaking going on!

Sky & Telescope said that hand-holding Canon image-stabilized binoculars was "a quantum leap in binocular observing." Canon's electro-mechanically stabilized images are rock-solid, not jittery and blurred, no matter how unsteady your hands. You'll simply see more deep sky detail than you can with conventional binos. There are 15 x 50mm and 18 x 50mm models that are excellent for astronomy. Full details are on our website.

More than 1,000,000 people a year visit our website for reliable info, helpful features, and secure on-line shopping.

www.astronomics.com

New Celestron ED eyepieces for only $64⁹⁵!

Celestron's new *six-element* ED glass 55° field **X-Cel eyepieces** set new standards in affordable eyepiece performance. They are available in 2.3, 5, 8, 10, 12.5, 18, 21, and 25mm focal lengths. These parfocal eyepieces are fully *5-layer multicoated,* with blackened lens edges for higher contrast. They have 20mm of eye relief for eyeglass use and come in protective plastic cases. ***At only $64.95 each,*** *they are incredible visual values.*

"Optics as good as I have seen . . . in any telescope . . . at any price."

TMB 105

A *Sky & Telescope* review said the **TMB** triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price."

Not only do the TMB ED apo refractors have optically unsurpassed triplet optics and precision mechanics (such as a 3" focuser), but many of the sizes listed in the next column are available from stock. Even those that may be temporarily out of stock are usually available again in few short *months, not* a few *years*, as is the case with another well-known brand.

Why wait years for another triplet apo when you can be observing with the best right now? For more details and pictures, visit our website to see the apo refractors that are the talk of experienced astronomers everywhere.

TMB 80/6 80mm (3.1") f/6	**$1690⁰⁰**
TMB 80/7 80mm (3.1") f/7	**1690⁰⁰**
TMB 105 105mm (4.1") f/6.2	**3290⁰⁰**
TMB 152 152mm (6") f/7.9	**6990⁰⁰**
TMB 175 175mm (7") f/8	**11,990⁰⁰**
TMB 203 203mm (8") f/9	**19,990⁰⁰**
TMB 254 254mm (10") f/9	**39,995⁰⁰**

Our free catalog helps you pick the right Celestron, Meade, Questar, Stellarvue, Takahashi, TeleVue, TMB, or Vixen scope.

For the most detailed and fully illustrated information on individual products, visit our web site at **www.astronomics.com**. Or you can get a *free* copy of our catalog AST by sending us an email or calling (405) 364-0858.

It includes our 8-page guide on how to pick the right scope, plus your discount prices on the 1500+ products we carry – from Antares, Astrozap, Canon, Celestron, Coronado, Discovery, Fujinon, JMI, Leica, Losmandy, Meade, Minox, Miyauchi, Nikon, Parallax, Pentax, Questar, Rigel Systems, SBIG, Sirius Optics, Sky Publishing, Software Bisque, Starbound, Starlight Instruments, Stellarvue, Swarovski, Swift, Takahashi, TeleVue, Thousand Oaks, TMB, Vernonscope, Vixen, Zeiss, and more. (Sorry, U. S. sales only.)

The catalog is yours for only the cost of a one minute phone call. The information and pricing we send will make it the most useful minute you'll ever invest in astronomy. Prices in this ad are current as of 3/10/03, but subject to change.

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7" to 10" Meade GPS scopes ship from stock.

Meade 8" LX200 GPS
$2495

The Meade LX200GPS telescopes have all the features you've dreamed about having since you started astronomy – plus you can get optional UHTC (Ultra High Transmission Coatings) optics that give you up to 20% higher light transmission so you can see 20% more of the Universe.

Meade's *fully automatic* GPS (Global Positioning Satellite) alignment system, with its true north and true level sensors and automatic magnetic declination correction, takes the time and guesswork out of setting up your scope. You'll be observing in mere minutes. The built-in computer, with a database of over 145,000 stars and objects, will find deep space and solar system objects for you *automatically.* You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them. We keep Meade LX200GPS scopes in stock. Chances are good we have one ready to ship to you.

New Celestron 5" to 10" go-to scopes start at $949 . . . prices you can afford.

Celestron C 9¼ SGT 9¼" go-to
$1699

Celestron's **Advanced Series** scopes put Celestron's renowned Starbright multi-coated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA has flown them on Space Shuttle missions) to a big 10" Newtonian reflector, there's a Celestron Advanced Series go-to scope that's just right for you and your budget.

The go-to scopes available include:

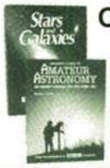
a 5" Schmidt-Cassegrain	**$1099**
a 6" achromatic refractor	**$999**
an 8" Schmidt-Cassegrain	**$1299**
an 8" Newtonian reflector	**$949**
a 9¼" Schmidt-Cassegrain	**$1699**
and a 10" Newtonian reflector	**$1149**

Each comes with a heavy duty adjustable height tripod that uses rigid 2" diameter steel legs instead of the lighter aluminum used in other telescopes. Their go-to computers have a library of 40,000+ stars and objects for you to observe. Dual-axis high speed slewing DC servo motor drives are standard. The list of standard features goes on and on – all at go-to prices starting as low as $949.

Celestron rechargeable battery for only $59⁹⁵!

Why pay $75 for a 7 amp-hour 12V DC rechargeable battery, when Celestron's new **Power Tank** does more for less? It has *two* cigarette lighter plug outputs, not one. It has separate 3, 6, and 9 volt DC outputs to power accessories; a red lamp to set up your scope, an emergency spotlight; recharger, carrying strap, and more. *Compared to $75 batteries with fewer features, it's an incredible value at $59.95.*

Observing books on sale for up to 50% off!



When we bought 4000 deep space observing books from *Astronomy Magazine* at one time, we got them at some very special prices. We're passing our savings on to you, pricing them as low as 50% off retail. Just take a look at your savings . . .

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The Stellarvue refractor is a "hot new product."

AT1010 **$499**
shown w/optional diagonal and eyepiece

The 78mm f/6.15 **Stellarvue AT1010** refractor was named a "Hot New Product" by *Sky & Telescope.* Independent reviews say this achromat competes favorably with semi-apo ED scopes that cost twice its modest price, and that it easily outperforms imported achromats in color correction and resolution. The AT1010 has triple tested hand-assembled optics, tube rings, tripod adapter, 2" focuser with 1.25" adapter and T-threads, red dot finder, oversize rubberized focus knobs for easier cold weather use, and a soft padded carry case. It's a super deal that's ready to ship now. We keep many Stellarvue refractors in stock, from 78mm to 102mm, *including APOs.*

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at www.astrofieds.com

Multicoated optics? They're standard on the NexStar 8 GPS.

NexStar 8 GPS
$2499

Celestron's **NexStar 8 GPS** Schmidt-Cassegrain has all the features you expect from a GPS scope (including Starbright high transmission multicoated optics for brighter images *at no extra cost)* plus some unique features unavailable in other GPS scopes!

For example, you can convert its unique Fastar 8" f/10 optical system to a blazingly fast f/1.9 focal ratio for wide field CCD imaging. With an optional Fastar lens assembly and a $1295 SBIG ST-237A CCD camera, the NexStar 8 GPS will record a huge 32 x 42 arc minute field. That's larger than the full Moon and more than three times the sky area imaged by a $7695 CCD camera on other 8" telescopes without Fastar optics!

Of all go-to telescopes, *only the Celestron NexStars have multicoated Fastar optics!*

The *new* Celestron CGE go-to telescopes. Designed to meet a mounting demand.

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Celestron CGE1100

Astrophotography with a fork-mounted go-to Schmidt-Cassegrain has its drawbacks. You can't use its altazimuth mount to take long exposure deep space photos without adding a costly equatorial wedge or field derotator. If you use a wedge, you can't image near the celestial pole or the southern horizon, and tube vibrations can become a problem. Use a field derotator, and you lose periodic error correction and can't image at the zenith. In larger apertures, fork-mounted scopes often require two people to transport and set up.

Celestron's CGE go-to German equatorial mount scopes solve these problems. Even the largest 14" CGE1400 can be set up by one person. The CGE German mount can access all parts of the sky, without the need for an optional and expensive wedge or field derotator. And German mounts are noted for their lack of vibration.

The Celestron multicoated CGE scopes are available as complete go-to systems in apertures from 8" to 14", or as a go-to mount only for use with your own optics. GPS is optional at only $199. Our website at **www.astronomics.com** has full details.

Only $899 for a 5" GPS-ready Celestron SCT!

NexStar 5i
$899
the Nexstar 5i is shown with optional photography accessories, tripod, and computer

The **Celestron NexStar 5i** is the *only* 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has GPS! Even better, the modular NexStar 5i lets you can build up to a full GPS system gradually, starting at only $899 for a complete working tabletop scope and adding a computer, GPS, etc., as wanted or needed.

Starbright multicoated optics are *standard equipment* with the Celestron NexStar 5i. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality?

CELESTRON

The new Celestron NexStar 8i modular 8" GPS-ready SCT starts at only $1199!

NexStar 8i
$1199
shown with optional tripod and computer

The **Celestron NexStar 8i** costs less than other comparably-equipped 8" go-to scopes. Starting at only $1199 for a dual-axis drive tabletop scope, you can add the options that you and your budget feel comfortable with. An *iCOMP* computer hand control with a 40,000 deep space object memory is $149. A lightweight travel tripod is $149. A heavy duty tripod (the same as used on the NexStar 11) is $299. If you want GPS (an unavailable option with other scopes), you can add it for only $199. No matter how you outfit your NexStar 8i, it's enough scope to keep you observing for the rest of your life, at a price that leaves other scopes behind.

Celestron's NexStar 11 GPS got a rave review. You can be enjoying yours next week!

$2999
NexStar 11 GPS

Celestron's 11" fork-mounted go-to GPS scope – the **NexStar 11 GPS** – got a *rave* review in *Sky & Telescope.* The review gave the scope "an enthusiastic two thumbs up and a gold star."

The magazine said the scope has "brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

Starbright multicoated Fastar-compatible optics are *standard* with the NexStar 11. Fastar optics are unavailable with other scopes. The NexStar 11 GPS is in stock. Call us today and you can have yours in about a week.

This is the best CCD book. *Period.*

Before you spend $3000 on a CCD camera, spend $49.95 on Ron Wodaski's book **The New CCD Astronomy**. It is simply the best and most complete imaging reference available for the beginning to advanced CCD astrophotographer.

Discovery Dobs are not cheap . . . just inexpensive.

8" f/6 DHQ
$449

Why settle for a so-so imported Dobsonian reflector when you can have made-in-the-USA quality for the same money? Discovery doesn't use inexpensive, imported, mass-produced optics that are only spot-checked to see if they're acceptable. Discovery optics are made in California by optical craftsmen, one quality mirror at a time. Each is hand figured to diffraction-limited performance, and it doesn't leave the Discovery optical shop until it's right.

Each 6" to 13.1" Discovery DHQ Dob has an adjustable metal primary mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* Plössl eyepieces, a 2" metal focuser with 1.25" eyepiece adapter, a unique built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finder, and a tube end dust cover. For only $49 more, you can have an upgrade package that gives you two more Plössl eyepieces, an eyepiece rack, a second dust cover, and a Moon filter!

Here are the prices for the 6" to 13.1" Discovery DHQ Dobs. Freight from the factory in California is additional, as shown.

6" f/5 Discovery DHQ	**$339⁰⁰**	+ $49 freight
6" f/8 Discovery DHQ	**339⁰⁰**	+ $49 freight
8" f/6 Discovery DHQ	**449⁰⁰**	+ $49 freight
8" f/7 Discovery DHQ	**449⁰⁰**	+ $49 freight
10" f/4.5 Discovery DHQ	**649⁰⁰**	+ $69 freight
10" f/5.6 Discovery DHQ	**649⁰⁰**	+ $69 freight
13.1" f/4.5 Discovery DHQ	**999⁰⁰**	+ $185 freight

Premium Dobsonians with many upgraded features and accessories are also available in 8" to 17.5" apertures starting at $799.

And for those who want both trunk-of-the-car portability and the light-gathering of a *big* aperture, Discovery has easy set-up truss-tube Dobsonians available in apertures of 12" to 24". Truss-tube Dob prices start at $1999.

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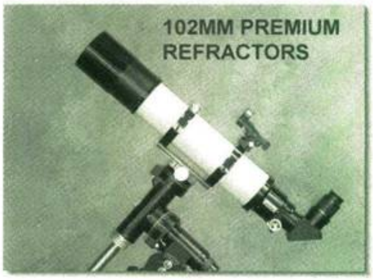

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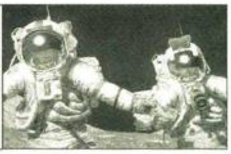

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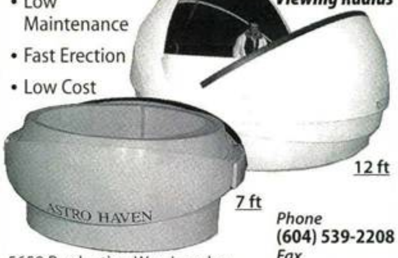

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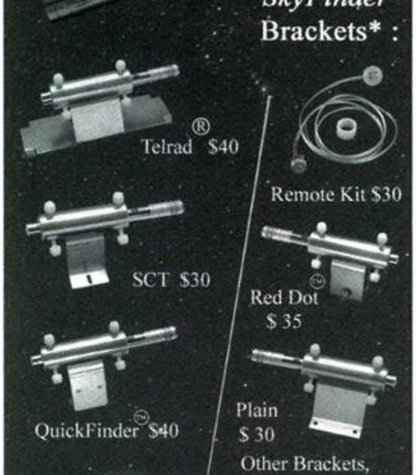

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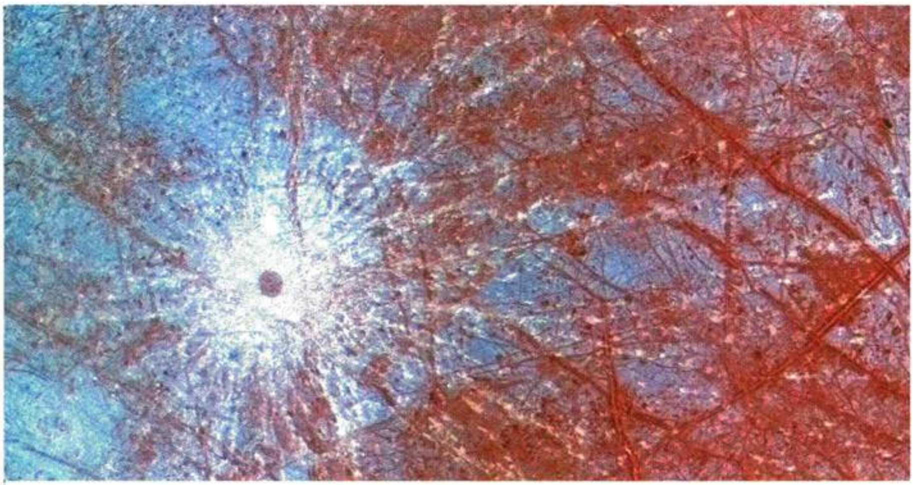

SPACE ODYSSEY will use spectacular, up-close imagery in the planetarium show Europa 2190 to take visitors on a simulated journey to Jupiter's moon. NASA/JPL/CALTECH

Space Odyssey, with its in-house scientists, digital media, planetarium, and exhibits, will keep pace with our rapidly developing knowledge of space science. Each visit should be fresh and unique, creating an unforgettable experience.

For more information on Space Odyssey, visit the museum's website, http://www.dmns.org

06.04.03–06.11.03; 06.17.03–06.25.03; 06.28.03–07.01.03

University of Arizona Alumni Association Astronomy Camp for Teenagers and Educators

Catalina Observatories, Tucson, Arizona. Beginner teens, June 4–11; advanced teens, June 17–25; educators, June 28–July 1. For more information, contact Don McCarthy at 520.621.4079; 933 N. Cherry Avenue, Tucson, AZ 85721–0065; e-mail, dmccarthy@as.arizona.edu; website, http://www.ethel.as.arizona.edu/astrocamp.

06.13.03–06.14.03

Apollo Rendezvous

Boonshoft Museum of Discovery, Dayton, Ohio. For more information, contact Rick Weiss at 937.669.5449; website, http://www.mvas.org.

06.21.03

Lake Whitney Girl Scout Star Fest

Lake Whitney State Park, Whitney, Texas. Open to Girl Scout Troop members; camping is available for participants. For more information, visit the Lake Whitney Astronomical Association's website, http://www.whitney-astro.com/.

06.21.03–06.28.03

Grand Canyon Star Party

Two sites at the north and south rims of Grand Canyon National Park, approximately 80 miles from Flagstaff, Arizona. For more information, visit www.tucsonastronomy.org/gcsp.html.

06.23.03–06.29.03

Laurel Highlands Star Cruise

Pine Hill Campground, near Hazleton, West Virginia. For more information, contact John Holtz at 724.352.7596; website, http://www.lhstarcruise.org.

06.27.03–06.28.03

Craters of the Moon Star Party

Craters of the Moon National Monument, near Arco, Idaho. For more information, contact Mark Brandon at 208.357.3540; e-mail, skygaze@allidaho.com; or Jay Sneddon at 208.736.2447; e-mail, jaysneddon@yahoo.com.

06.27.03–06.29.03

Jersey StarQuest 2003

Hope Conference and Renewal Center, Hope, New Jersey. For more information, contact Anthony Monticello, 270 Fieldboro Drive, Lawrenceville, NJ 08648; e-mail, anthony_monticello@hotmail.com; website, http://www.princetonastronomy.org.

07.19.03–08.08.03

International Astronomical Youth Camp

Jugendherberge Aschberg, Klingenthal, Germany. The IAYC is a three-week camp for English-speaking students, ages 16–24, who are interested in astronomy. For more information, visit the IAYC website, http://www.iayc.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our online calendar at http://www.astronomy.com.

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RESOURCES

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CRUX, MUSCA, AND CIRCINUS

BOOKS — Ambitious observers who would like to pursue additional interesting objects should consult *Sky Catalogue 2000.0, Volume 2: Double Stars, Variable Stars and Nonstellar Objects* (Sky Publishing and Cambridge University Press, Cambridge, Massachusetts, 1985). This comprehensive listing, edited by Alan Hirshfeld and Roger W. Sinnott, not only includes double stars and variable stars, but also star clusters, nebulae, galaxies, quasars, and other radio and x-ray sources.

For those who are enchanted by the ghostly forms of planetary nebulae, Steven J. Hyne's *Planetary Nebulae: A Practical Guide and Handbook for Amateur Astronomers* (Willmann-Bell, Richmond, Virginia, 1991) is a valuable companion. Containing a list of 1,340 nebulae, the book also includes sketches, tips on observing these objects, more than 250 finder charts, and other information nebula lovers will enjoy.

DEPTH PERCEPTION IN ASTRONOMY

BOOKS — In this issue, James Mullaney lists a number of solar system and deep-sky targets and explains how to appreciate their distances. The latest edition of his book, *Celestial Harvest: 300-Plus Showpieces of the Heavens for Telescope Viewing and Contemplation*, provides information on more than 300 objects, many of which can be observed with unaided eyes under dark skies (Dover Publications, New York, 2002).

ARTICLES — For more tips on training your eyes and increasing your observing enjoyment, revisit "The Art of Seeing," an article by Michael Porcellino (*Astronomy*, February 1990).

THE MOON

BOOKS — Sending humans to the Moon was one of the great accomplishments of the 20th century, and returning to our natural satellite may well rank high in the 21st century. A wealth of information on these quests can be found in print. Check out the *Lunar Base Handbook* by Peter Eckart (McGraw-Hill, New York, 1999) and *The Once and Future Moon* by Paul D. Spudis (Smithsonian Institution Press, Washington, D. C., 1996).

ARTICLES — For further reading, see "Observatories on the Moon" by J. O. Burns, N. Duric, G. J. Taylor, and S. W. Johnson (*Scientific American*, March 1990) and "Mining the Moon" by D. M. Burt (*American Scientist*, November/December 1989).

IMAGING THE SUN IN Hα

BOOKS — Amateur observers may enjoy the comprehensive and somewhat technical *Solar Astronomy Handbook* by Rainer Beck, Heinz Hilbrecht, Klaus Reinsch, and Peter Völker (Willmann-Bell, Richmond, Virginia, 1995), or *Observing the Sun* by Peter Taylor (Cambridge University Press, New York, 1991).

WEB — For astrophotographers who still use 35mm cameras and film, check out some pointers from veteran solar photographer Jean Dragesco in two online articles — "Sunsational Photography," at http://www.astronomy.com/content/dynamic/articles/000/000/000/535kkcim.asp, and "Tips From an Experienced Hydrogen-Alpha Photographer," at http://www.astronomy.com/content/dynamic/articles/000/000/000/536aglfa.asp.

LONELY PLANETS

ARTICLES — A number of popular articles in the last few years have been written about these undefined, planet-sized objects. Good introductions include "Free-Floating Planets and Stellar Clusters" by Jarrod R. Hurley and Michael M. Shara (*American Scientist*, March/April 2002) and "Giant 'Planets' on the Loose in Orion?" by Robert Irion (*Science*, October 6, 2000).

WEB — For an enlightening animation of how these objects may form, check out University of Exeter astrophysicist Matthew Bate's website at http://www.astro.ex.ac.uk/people/mbate/Research/pr.html (scroll down to "Animations").

PLUTO

BOOKS — For a vivid account of the discovery of Pluto, pick up a copy of *Out of the Darkness: The Planet Pluto* by Clyde W. Tombaugh, who discovered this elusive planet in 1930, and astronomer Patrick Moore (Stackpole Books, Harrisburg, Pennsylvania, 1980). For information on the modern research being done on our most distant planet and its moon, read *Pluto and Charon* by Alan Stern and Jacqueline Mitton (John Wiley & Sons, New York, 1998).

ARTICLE — Andrew Cheng, of the Johns Hopkins Applied Physics Laboratory, gives an overview of NASA's most recent proposed mission to Pluto in "Pluto or Bust" (*Astronomy*, May 2002).

WEB — Since the year 2000, the Pietro.org astronomy website has offered the "Pluto Challenge" during prime viewing months. The site offers tips, sky charts, images, and forums for observers to post their thoughts and observations. The 2003 Challenge begins this month, so check out http://www.pietro.org/Astro_C5/Articles/PlutoCurrent.htm.

SIGNS OF LIFE

BOOKS — Several excellent books have appeared in the past few years that discuss the search for exoplanets as well as the possibility of extraterrestrial life. Among the best are: *Distant Wanderers: The Search for Planets Beyond the Solar System* by Bruce Dorminey (Copernicus Books, New York, 2002); Pale Blue Dot by Carl Sagan (Random House, New York, 1994); *Rare Earth: Why Complex Life is Uncommon in the Universe* by Peter D. Ward and Donald Brownlee (Springer-Verlag, New York, 2000); and *The Search for Life on Other Planets* by Bruce Jakosky (Cambridge University Press, New York, 1998).

Must-See Issue!

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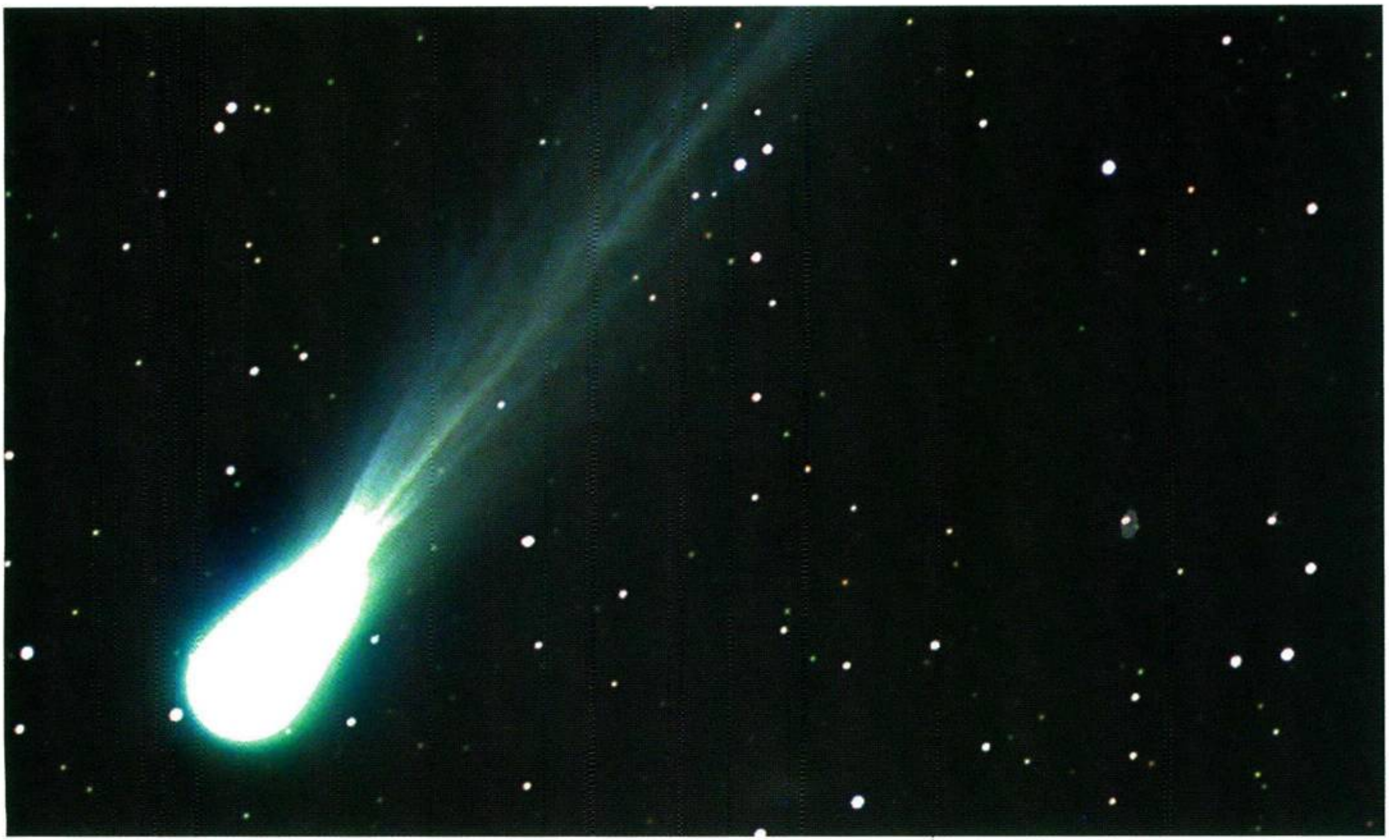
Reader gallery

Readers share their images...

Comet NEAT /// The Orion Nebula /// Canadian aurora /// Orion star trails
Big Dipper and church /// Conjunction of the Moon, Venus, and Mars



Above, **COMET C/2002 V$_1$** (NEAT) (Meade 7-inch apochromatic refractor at f/9, Finger Lakes Dream Machine CCD camera, 2-minute exposure taken February 3, 2003) /// **JACK NEWTON**

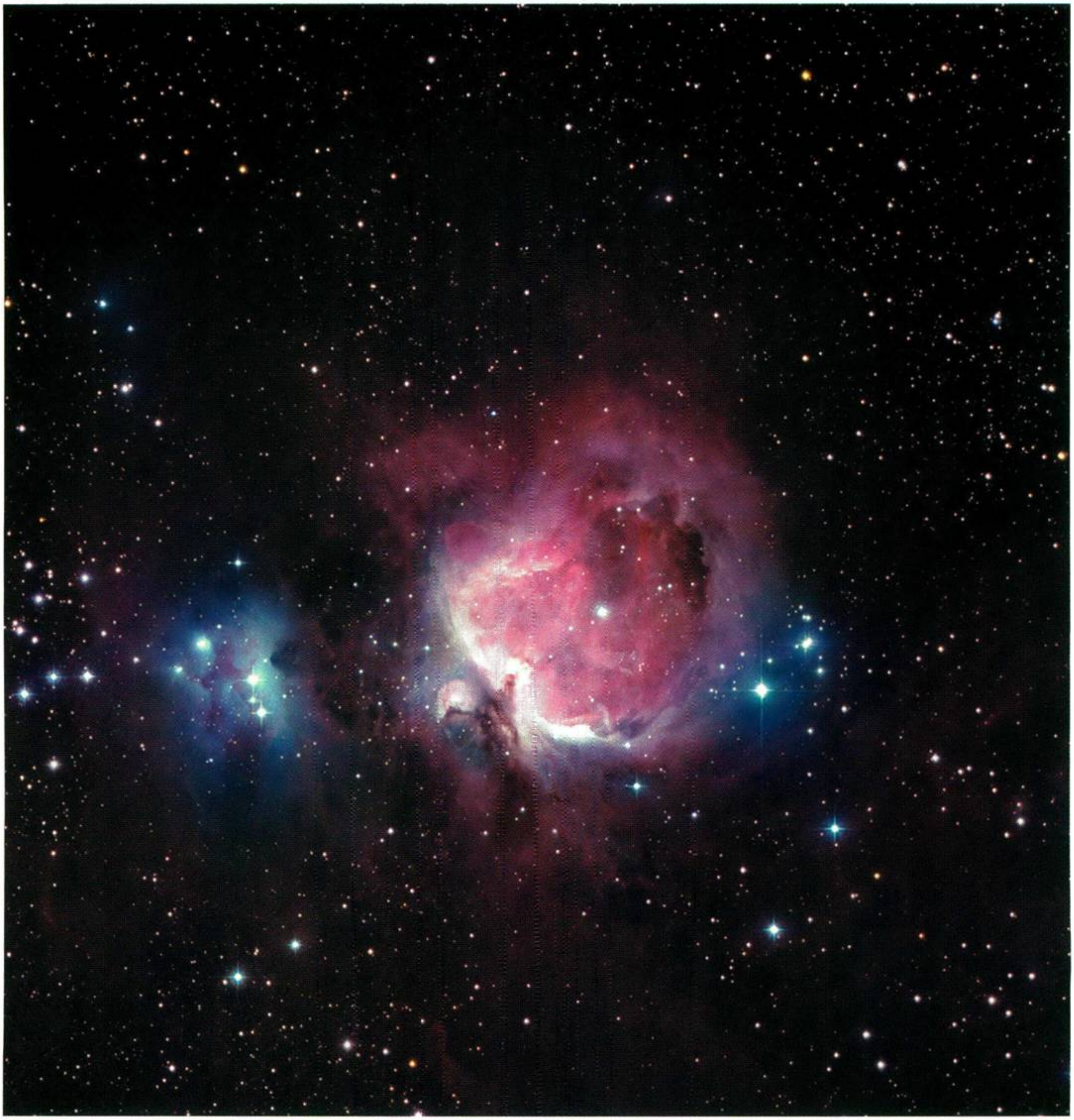
IMAGING COMETS

Comet NEAT

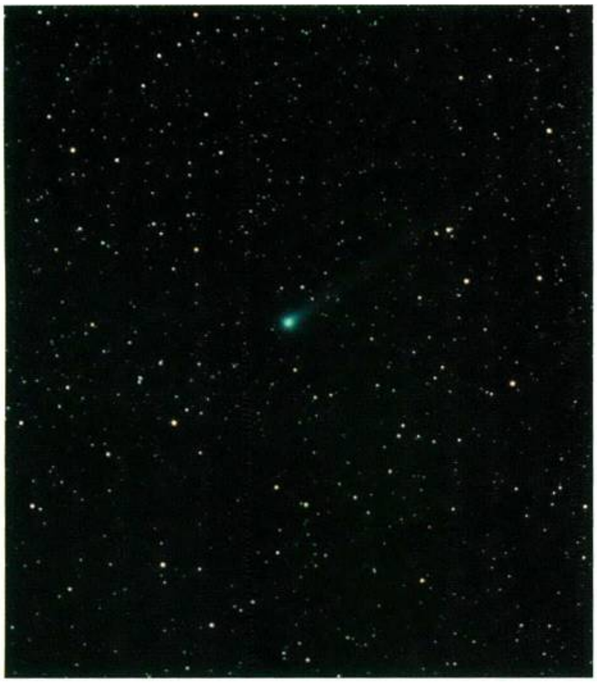
The Near Earth Asteroid Tracking (NEAT) program discovered Comet C/2002 V$_1$ in November 2002. Dubbed Comet NEAT, it brightened to naked-eye visibility in early February. Eagle-eyed observers were able to catch the bright comet without the help of a telescope or binoculars until it disappeared into the Sun's glare in mid-February.

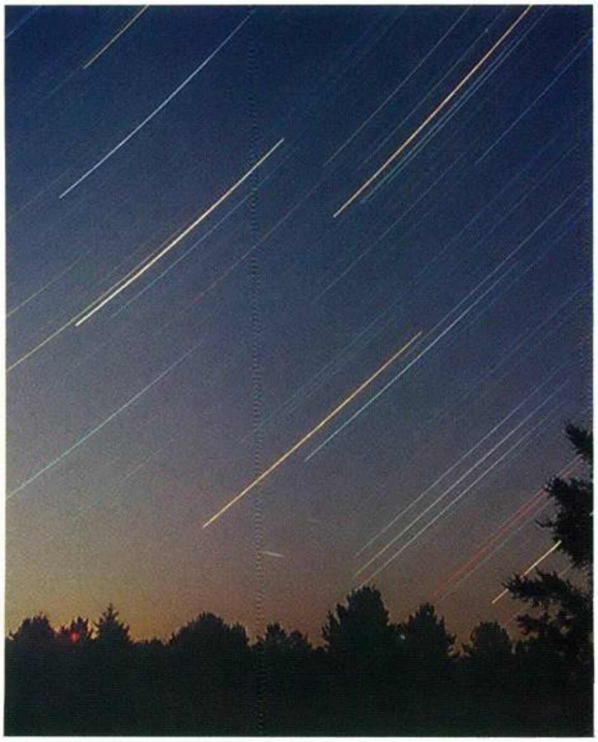
Jack Newton captured this stunning image of Comet NEAT from the Arizona Sky Village community, near Cave Creek Canyon in Portal, Arizona.

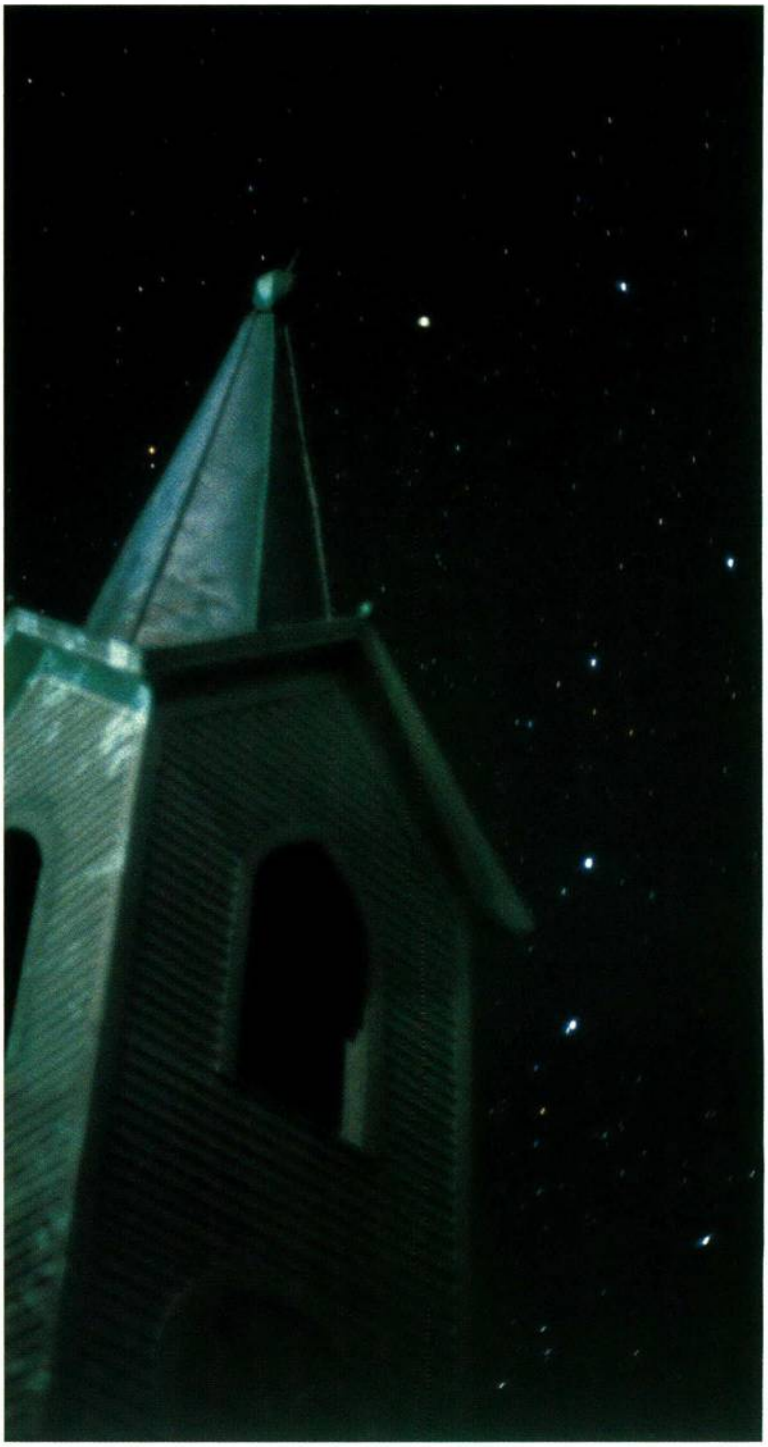
Send your photos to: ASTRONOMY reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com.
Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.



Above. **THE ORION NEBULA** (M42) (12.5-inch homemade Newtonian reflector at f/7, hypered Kodak 400 film, composite exposure) /// **BOBBY MIDDLETON**







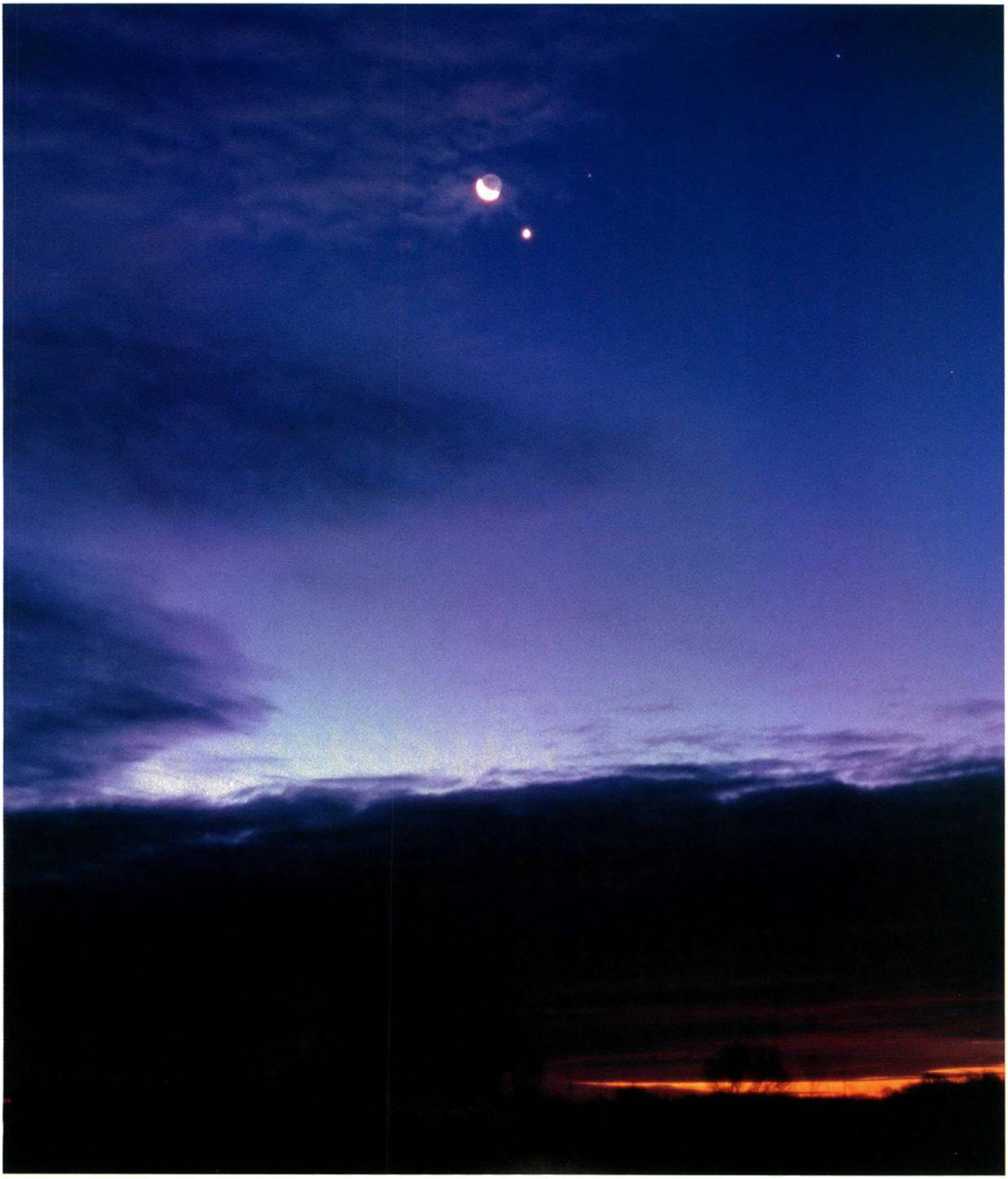
Left. **CANADIAN AURORA** [Sony Cybershot DSC-707 digital camera at f/2, 30-second exposure taken October 1, 2002, near Calgary, Alberta, Canada] /// **GEORGE SUMMACH**

Top left. **COMET C/2002 V_1** (NEAT) [Celestron 8-inch Schmidt Camera at f/1.5, 6-minute exposure taken January 24, 2003, in Happy Jack, Arizona] /// **CHRIS SCHUR**

Bottom left. **ORION STAR TRAILS AND IRIDIUM FLARES** [28mm lens at f/2.5, Fuji Provia 400 film, 90-minute exposure taken August 20, 2002, in northern Wisconsin] /// **STAN RICHARD**

Right. **BIG DIPPER AND CHURCH** [50mm lens at f/2, Kodak Elitechrome 400 film, taken May 15, 2002, near Willmar, Minnesota] /// **CARLA WEHLER**

Below, **CONJUNCTION** of the Moon, Venus, and Mars [50mm lens at f/2, Kodak Elitechrome 200 film, 3-second exposure taken December 1, 2002]
/// **RANDALL WEHLER**



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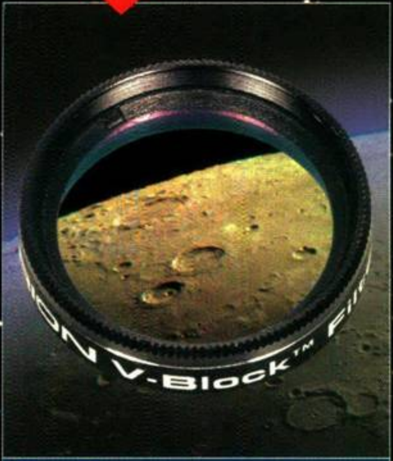

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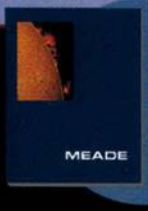

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